Papers relating to the
Cuttack Rivers
Part 1

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OF THE

GOVERNMENT OF BENGAL.

N°. XXXV.

PAPERS

RELATIVE TO THE

CUTTACK RIVERS.

PART I.

Published under the orders of the Government of India, P. W. D. No. 365, dated 17th January, 1860.

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1860.

CORRESPONDENCE

REGARDING THE

GENERAL STATE OF THE EMBANKMENTS IN CUTTACK

AND

THE DISTRIBUTION OF THE FLOODS IN THE POOREE AND CENTRAL CUTTACK DISTRICTS.

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PAPERS

RELATING TO

THE CUTTACK RIVERS.

From Chief Engineer, Lower Provinces, to the Secretary to the Government of Bengal, Public Works Department, Fort William,—(No. 2315, dated 9th August, 1855.)

SIR,

I HAVE the honor to annex, for the information of Government, copy of a communication, No. 904, dated 4th August current, from the Superintendent of Embankments reporting the occurrence of an extraordinary flood in the Mahanuddy River and its branches.

2. Captain Beadle states that the flood attained the extraordinary height of 27.35 feet on the 29th ultimo, being 3 feet higher than the floods which caused so much damage last year, and that if the revetment wall had not been raised in height this season, the city of Cuttack would have been probably destroyed.

3. Favorable mention is made of the energetic exertions of Assistant Overseer J. McMillan, whose conduct the Executive Engineer reports as deserving of some acknowledgment.

4. The Superintendent of Embankments promises a further report on the district of Pooree, where, it is feared, considerable damage must have been sustained, the rivers not being capable of passing off, within the Embankments, such a flood as has occurred.

5. On receipt of Lieutenant Harris' project for the disposal of the Mahanuddy floods referred to in the 9th para. of Captain Beadle's communication, I will submit a report to Government.

From the Superintendent of Embankments, to the Chief Engineer, Lower Provinces, Fort William, Midnapore,—(No. 904, dated 4th August, 1855.)

SIR,

I HAVE the honor to report that a very extraordinary flood has occurred in the Mahanuddy and its branches.

2. On the 27th July at 6 A. M., the flood in the Katjooree rose 17.83 on the Cuttack guage; on the 28th at the same hour the waters were 22.5 on the guage; at 1 P. M., 23.5.

3. Last year during the great flood that occurred, the rise was 24.5 on the guage.

4. At 7 P. M. on the 28th, the floods equalled those of 1823; at 2 P. M., on the 29th July they attained the extraordinary rise of 27.35 feet.

5. The revetment wall has been raised in height during this season, and it is owing to this, that Lieutenant Harris attributes the saving of the city of Cuttack, and to the conduct of Assistant Overseer J. McMillan, whose name Lieutenant Harris solicits may be brought to the favorable notice of Government.

6. It was through the sustained energy and exertions of McMillan that the Executive Engineer was able to keep in three detached places parapets of sand bags backed with earth rising above the river, which rose steadily two inches an hour, and Lieutenant Harris says that the Assistant Overseer's conduct was beyond praise and should meet with reward.

7. The Executive Engineer's letter dated the 30th, says, that the floods have subsided ¼ foot in the last 24 hours, and that the waters have every appearance of passing off quietly.

8. I shall write immediately on receiving further communications from Lieutenant Harris. We must expect very bad news of the Pooree district, the rivers of which are not capable of passing off within the Embankments such a flood as has occurred, a flood 3 feet higher than that which last year caused so much damage.

9. Lieutenant Harris is grappling with the great question of the disposal of the Mahanuddy floods, and from his letters, I believe, he will work out the problem, which he is intent upon doing.

10. I have my own views on the subject and having corresponded freely on all points with the Executive Engineer, am now waiting for

Lieut. Harris to mature his project and fortify his plans with certain data which are still wanting to enable him to develope his scheme for the relief of the Katjooree and Kokai rivers. He hopes to have his project prepared by the end of the rains.

From LIEUT.-COL. W. E. BAKER, Secretary to the Government of India, to W. GREY, ESQUIRE, Secretary to the Government of Bengal,— (No. 14, dated 5th January, 1856.)

SIR,

I AM directed to acknowledge the receipt of your letter, No. 2475, dated the 4th ultimo, with original enclosures, and in reply to state that the Most Noble the Governor-General in Council approves of the recommendation of the Hon'ble the Lieut. Governor of Bengal, that Lieut. Harris be relieved from the details of the Cuttack Office and Embankments, and be employed in making a comprehensive survey of the rivers of the Province, &c., as proposed by the Superintendent of Embankments.

2. The arrangement proposed by Captain Beadle for carrying on the duties of the Cuttack Division of Embankments when relinquished by Lieut. Harris, involving a monthly expenditure of Rupees 188, is also approved of.

3. The original documents received with your letter are returned, and you are requested to furnish this department with copies of them.

No. 118, dated 8th January, 1856.

COPY forwarded to the Chief Engineer, Lower Provinces, for information with reference to his letter, No. 4185, dated the 16th November last, and original enclosures returned, copies having been kept for record.

By Order of the Lieutenant-Governor of Bengal.

REPORT ON THE MAHANUDDY RIVER.

From COLONEL H. GOODWYN, Chief Engineer, Lower Provinces, to the Secretary to the Government of Bengal, Fort William, (No. 2372, dated 13th September, 1856.)

SIR,

REFERRING to your letter, No. 118, dated 8th January, 1856, and its enclosure, from the Secretary to the Government of India, in the Public Works Department, relieving Lieutenant J. C. Harris, Executive Engineer, Cuttack Division, from the charge of his Office, for the purpose of conducting a comprehensive survey of the rivers of the Province, with a view to the consideration of the best means of controlling the rivers and securing the town of Cuttack from the dangers by which it is threatened, I have now the honor to submit, for the information of His Honor, the Lieutenant-Governor, the accompanying Report and Drawings by Lieutenant Harris, embodying the result of the labours of himself and his Assistants* during the past season, as far as relates to the Mahanuddy above Cuttack, and its effect upon that town.

2. He describes the course and capacity of this river from Bydessur to Naraj, a distance of 29 miles, whence the Mahanuddy emerges, with great velocity, from a rocky gorge only ⅛ mile broad, into a wide basin situated just above Cuttack, in width 3 miles, and length from Naraj to the head of the town, 4 miles. At this point, or head-land of the Delta, the Mahanuddy diverges into several streams, the two principal ones, viz. the Mahanuddy Proper and Katjooree flowing respectively on the North and South borders of the town.

3. As the river debouches from Naraj into the open space before it, its velocity becomes diminished, silt is deposited in the bed, to compensate for which, lateral action upon, and erosion of, banks ensues. The northern bank appears to have yielded until a rocky limit was arrived at, but the southern shore is still undergoing abrasion, and thus the heads of the Kokai and Katjooree, two of the effluents on this side, have become considerably enlarged and now admit more than a due proportion of the waters of the Mahanuddy.

4. After entering minutely into the facts and phenomena of the Mahanuddy River and the imminent danger threatening the town of

* Messrs. Smallwood, Kellock, and Overseer McMillan.

Cuttack, which arises principally from the increased volume of water now flowing into the enlarged bed of one of its effluents, viz. the Katjooree River, Lieutenant Harris proposes a remedy by the construction of an incomplete or sunken weir in the bed, extending like a spur from the right bank at Naraj in the direction of Temple Island upon the northern shore, to a distance of 4,900 feet, which he anticipates will have the effect of turning a considerable portion of the water, which now passes off by the Katjooree into the Mahanuddy Proper. However Lieutenant Harris is of opinion that, if the permanent safety and well-being of the city were a prominent consideration, and the work could be extended over a long term of years, a complete weir from Naraj to the head of the town of Cuttack would be more desirable.

5. The sunken or incomplete spur, Lieutenant Harris estimates, might be constructed for Rupees 1,50,000, but the Superintendent of Embankments considers it would be safer to estimate it at Rupees 2,00,000, and in addition to the sunken spur considers it would be necessary to have one of two other works, shown in a Sketch Plan marked A., submitted by him. One of these works being a continuous dam across the bed of the Katjooree between Chargurreah and the stone revetment at Cuttack, the other, and more preferable, being a continuous dam, 14 feet in height, across the Kokai, round the point of land and across the Katjooree bed; in either work lock-gates and sluices would be requisite in the bed of the Katjooree.

6. But in lieu of the sunken spur at Naraj and either of the consequent works, the project which the Superintendent of Embankments would prefer (and for which he submits a rough estimate, amounting to Rupees 3,50,000) would be a continuous weir across the basin connecting Naraj with the head of the town of Cuttack by a curvilinear bank of rubble stone, over which high-floods would spill, and along which he supposes the waters would flow until they cross to the deep channel which would form along the left bank of the Mahanuddy, instead of round the extremity of Lieutenant Harris's spur and down the revetted side of the town. By this means, also, he anticipates the Beropa would be cleaned out and again become a river, as in the opinion of Lieutenant Harris, it would be the best channel to make navigable.

7. I would here refer to the outline of a project by Captain Short, Engineers, formerly Executive Engineer of Cuttack, dated

February 1855, which I am inclined to view favorably, whereby he proposed to attain the same result as Lieutenant Harris and Captain Beadle, by the construction of an artificial tongue or promontory formed of two legs of masonry, (*vide* Sketch C.,) to cause the volume of flood, immediately after emerging from the gorge above Naraj, to diverge in proportion to the capacity of channels of the two principal affluents. In addition to the masonry spur, however, it would be requisite to continue a sunken weir connecting the lower leg or face of the spur with the point of land above Cuttack, as shown by dotted red lines in the Sketch referred to.

8. It will be seen above, that the projected works have the same object, viz. to restore the equilibrium of the channels by clearing out the bed of the Mahanuddy, and reducing the discharge of the Katjooree, thereby decreasing the danger threatening the town of Cuttack; whichever project may be finally approved, the stone that is being collected from the Naraj Hills, will be equally available; but before any decided recommendation can be made, or the works allowed to be commenced upon, there are several points which have yet to be solved, and are recorded in the annexed copy of letter to the Superintendent of Embankments, wherein I have entered my instructions in full.

9. For satisfactory proof on these heads, we must await the result of Lieutenant Harris's labours during the ensuing season, which will be chiefly devoted to the effects of the Mahanuddy floods on the districts of Pooree and Cuttack, and the capacity of the several channels, and particularly the improvement of the upper portion of the Mahanuddy and the practicability of the formation of a reservoir in the upper reaches, with a channel between the upper Cuttack districts and the Chilka Lake navigable throughout the year.

10. The Superintendent of Embankments has also submitted a tabular Statement with his letter, No. 1009, dated 29th August, 1856, of the subordinate establishment required by Lieutenant Harris in conducting the field operations of the Survey and for his temporary Office, amounting in the aggregate to Rupees 230 per month, for the various periods specified. To this establishment, I would request sanction, as it appears very moderate. I would beg to solicit the attention of His Honor, the Lieutenant-Governor, to the activity and zeal with which the levels and survey operations hitherto have been conducted by Messrs. Smallwood, Kellock, Lieutenant Harris, and Overseer McMillan, and

to the very creditable manner in which the drawings and information have been prepared and arranged by Lieutenant Harris, containing as they do, not only valuable facts in regard to the present state of these rivers, but important data on which to base future operations. The whole, including some admirable sketches of Captain Beadle's, which heighten the interest, I at present submit, that Government may be acquainted with the nature and extent of the labour that has already been bestowed towards the remedying of a serious evil in the Cuttack district, and that, approval may be given to the furtherance of the same, during the next season by the continuance of the levelling operations.

I request the return of the original Drawings and Reports when perused, of which there are no copies any where, in order that, on the receipt of the second portion of the Survey, I may be prepared to submit my opinion on the complete project.

From COLONEL H. GOODWYN, Chief Engineer, Lower Provinces, to the Superintendent of Embankments, Lower Provinces. Fort William,—(No. 2371, dated 13th September, 1856.)

SIR,

I HAVE the honor to acknowledge the receipt of the letters noted in the margin, relative to the very interesting and ably-illustrated Report of Lieutenant Harris on the Mahanuddy river, and to state that the temporary establishment applied for in your letter, No. 1009, has been favorably recommended for the sanction of Government.

No. 982, dated 14th August, 1856.
No. 1009, dated 16th August, 1856.
No. 1055½, dated 21st August, 1856.

2. With reference to the 69th paragraph of your letter, No. 1055½, requesting sanction to your collecting stone material and stacking it in the line of the weir specified in the rough estimate submitted by you, I have to point out to you that the sanction of Government to the collection of stone was accorded in the copy of a letter, No. 2146, dated 15th October, 1855, forwarded to you with my letter, No. 4344, dated 22nd November, 1855, but I am not at present prepared to recommend the actual commencement of the proposed work as apparently implied in the sanction requested by you.

3. Referring to the Index Map, showing the several lines of levels proposed to be taken during the ensuing season, and in addition to

those noted by you in the 3rd paragraph of No. 1009, I should wish to have a line of cross-sections taken from the Bargony river to the Beropa, parallel nearly to the coast line, and the levels of the Daib river to be continued down to this line as shown by the dotted pencil line in the Index Map returned herewith.

I beg you will communicate to Captain Harris and accept yourself my sense of the value and importance of the report, data, and drawings submitted, and which I have favorably reported on to Government.

5. Captain Short too, is entitled to praise for the outline of his project, inasmuch as it presents a probable means of avoiding the evil likely to be felt by the obstruction of the dry weather stream from the bed of the Katjooree; but I will hazard no opinion yet, till the whole is more fully developed.

6. In order to secure this end, I conceive that the levelling operations in Cuttack, during the approaching winter, should decide the following points, which are essential to the thorough comprehension and undertaking of any scheme which has for its aim the control and regulating of the waters of the Mahanuddy:—

I. What volumes, in cubic feet per second, are proposed to be discharged down the several effluents of the Mahanuddy after its debouchure from Naraj at full, ordinary, and low water levels, viz. in the Barrany, Kokai, Katjooree, Mahanuddy, and Beropa rivers?

II. Are the lower channels and branches of these rivers capable, in their present condition, of discharging, without overflow, the several volumes allotted to them?

III. It is necessary to have clear and detailed proof of this, so as to place the facts of the present state and capacity of each channel beyond doubt.

IV. If it be ascertained, that by reason of the construction of embankments or any other cause, the area of any channel is too restricted to carry off its legitimate volume, what means are proposed to obviate this inconvenience?

V. Whether by raising or retiring the embankments, so as to afford more water-way, giving up any waste lands to inundation, so as to relieve the rest in its vicinity from danger, or by the excavation of new channels and the formation of reservoirs for its surplus waters, so as to diminish the discharge: all these measures merit consideration, but the one, advocated in each case, should be carefully and patiently arriv-

ed at, and the calculations and grounds upon which based, should be collated and fully explained.

VI. If the proposed operations should end in obstructing the dry weather stream from any particular bed, down which it has hitherto flowed, will the villages along the banks of such channels suffer from the contemplated withdrawal of the summer stream?

VII. After the proper distribution of volume is made to the several rivers with reference to their capacity of discharge, what means of irrigation will be afforded, or will any stream become navigable throughout the year?

VIII. The limit of tidal influence in each channel should be observed and marked in a Map, with reference to the most eligible and direct water routes from various points in the Delta to the sea, with some account of the bars and obstructions along the beds and at their estuaries.

IX. The seasons most propitious for navigation should be noted, and the facilities for the formation of good harbours and secure roadsteads, if any required, should be ascertained, also the nature of the line of sea coast.

X. The present tonnage, value and description of traffic concerned, both imports and exports, population and wealth, and extent of Delta, would be valuable data towards the elucidation of any general scheme advanced.

XI. What means and extent of irrigation are now employed, and whether the ryots are ready and capable of appreciating at once the benefit arising from an improved system of irrigation and agriculture, or will such effect result only from long experience?

XII. What descriptions of boats or other vessels are at present employed upon the navigable rivers of Cuttack, if steamers were employed, are the banks of the channels of a nature capable of withstanding erosion, and of what draught, form, and size should the vessels be?

7. The above heads are the principal points to which I wish your attention to be drawn, in addition to the remarks already made by you on this subject. With regard to the mode of protecting the town of Cuttack, until the final resolution of Government on these projects has been obtained, you will be good enough to submit a report of the effect of the last season's brushwood operations applied for the purpose of silting up the base of the revetment wall.

From the Superintendent of Embankments, to the Chief Engineer, Lower Provinces.—Midnapore, (No. 1055½, dated 21st August, 1856.)

SIR,

I HAVE the honor to submit a Report and Plans received from Lieutenant Harris embodying the Surveys made, and information obtained from them, of the Mahanuddy River above Cuttack, and of its division into the two channels which enclose the fork on which the Town of Cuttack and Fort Barabutty stand, protected from inundation and from encroachments of the river by revetments of stone masonry constructed in ages gone by, by the Mahrattas.

The Report is voluminous and the Plans are many, I think it well therefore to embody a running abstract of the former, and a description of the latter, which will serve to indicate the information afforded in these creditably-conceived and conducted proceedings of Lieutenant Harris, appointed to survey and report upon the Mahanuddy or great river of the Cuttack Districts.

2. Lieutenant Harris was appointed to the Survey of the Cuttack Rivers by Government letter No. 14, dated 5th January, 1856, on the recommendation contained in my No. 1312,* dated 12th September, 1855, and he was assisted in the Survey operations, shown in the Plans submitted, by Mr. Smallwood, Sergeant Fennessy, and Corporal McMillan.

3. Sergeant Fennessy was obliged, by sickness, to quit the Cuttack Districts, and his place was filled up by the appointment of Mr. Kellock, whose work will appear in the subsequent Report, to be submitted by Lieutenant Harris, which will not be prepared till the end of this season and will set forth the effects of the Mahanuddy floods on the Districts of Pooree and Cuttack and show the capacities of the several channels, and enter particularly into the question of the improvement of the Mahanuddy channel, and the formation of a navigable stream throughout the year, to connect the Upper Cuttack Districts with the Sea.

4. I now take up the Report.

Lieutenant Harris, quoting "Stirling," assigns the following dates to the construction—

* And 1439 of 24th September, and 1599 of 8th October.

4th Paragraph.

Of the city of Cuttack ..... A. D. 989,
Of the Revetment ..... A. D. 1006,
Of the Barabutty Fort. ..... A. D. 1174.

7th Paragraph.

He states that the Mahanuddy (great river), has always been the main channel, that the Beropa has also always had the character of a river, but that the Katjooree (Kat, a log; joora, small nullah,) was originally insignificant, having received its name from being crossed by a log of wood, also that its branch, the Kokai, (khoa, a crow, khye, a hollow,) was only a hollow wherein the crows assembled to drink water.

5. Lieutenant Harris states, that before the construction of the revetment, the site of the City of Cuttack must have been, in many places, a swamp inundated by moderate floods and swept over in every part by high floods; and that the gravelly soil now to be found there is foreign matter and does not belong to the natural soil.

6. Lieutenant Harris conceives that the levels have not altered much since the city was founded, but that the conditions of the rivers have changed materially, and as alterations in a light soil under the agency of running water are so rapid, he would rather conclude that some original advantages possessed by the site have disappeared than that the city was injudiciously founded; and he states that the greatest change has been in the Katjooree River, which he thinks was not an original channel of the Mahanuddy; he shows that the head of the Katjooree is proved by comparison of Surveys to have widened one-third of a mile in the last (15) fifteen years, and that its channel is altogether

13th Paragraph.

disproportioned to its head, which has increased so rapidly in size within the period of recorded observations. He points to the supersession of half of the old revetment wall on the Katjooree side of the town by a carefully built wall of greater height and larger dimensions, whilst the revetment wall on the Mahanuddy side has been neglected without ill result.

7. I must here remark that Lieutenant Harris draws a conclusion

15th Paragraph.

that the Katjooree has been formed from an insignificant stream in the lapse of a few centuries. I cannot coincide in this conclusion, for the construction of the revetment is referred to A. D. 1006, it is therefore eight and a half centuries since the two sides of Cuttack were faced with a revetment wall of similar construction, height, and strength, from which I should infer that at that time both sides were subjected to a somewhat similar danger.

Lieutenant Harris describes the city of Cuttack and the revetments.

17th Paragraph. He states that one of the principal roads in the city is 7 feet lower than the inclined plane (3 feet in a mile*) connecting the highest flood levels of the two rivers. He says that the revetments have no foundations below the bed of the river, and may at

20th Paragraph. any time be undermined, the path of the current being along the foot of the wall on the Katjooree side.

8. It is not during high floods that the breaches occur, and Lieutenant Harris attributes the failures in the revetment to the waters

23rd Paragraph. in the river subsiding much more rapidly than the moisture in the light soil backing up the wall which presses against it and works underneath it to gain the lower level in the river, bringing down the wall, which has been previously denuded of sand at foot by the action of the freshes.

9. Lieutenant Harris next describes the Mahanuddy River above Cuttack. His levels have commenced at Bydessur, where the river for 34 miles, has had a width of 2 miles, which continues to 12 miles below it, (Plate I.,) after which it narrows in the passage between the Rootrapoor and Domepatrah Hills, and issuing from between these boundaries expands to a greater width than before; and lastly, contracts to

28th Paragraph. less than half a mile in the rocky neck, from which it descends over the plains to the sea; the distance between Bydessur and Naraj Rock terminating, the neck being $27\frac{3}{4}$ miles.

From Naraj to the sea the length of the Mahanuddy is $67\frac{1}{2}$ miles, and taking the Pyka branch it is 69 miles.

The river above Naraj is described as a series of basins of various

29th Paragraph. lengths, depths, and breadths, caused by the limits, both laterally and vertical, assigned to its bed by hills and rocks. In the passage between Sydessur and Dewakote Hills a sounding was made showing 80 feet of water, the bed being excavated $16\frac{1}{2}$ feet deeper than the mean level of the sea.

The course of the river, as far as Naraj, is rock-bound; and Lieutenant Harris states that "the bar to any general change in the river's course between the points named is most complete." Passing Naraj the waters are let loose and have free action on the right bank of the Mahanuddy, which they have cut away, forming a large basin,

* This is fall per mile between the high flood-marks of the Katjooree and Mahanuddy, the distance being 2 miles, and difference of level 6 feet.

which is now the head of the Katjooree River; and the waters here find the shortest passage to the sea and have cut a deep channel, past the revetment, which will produce down the bed alternate lateral action and pooling, until the lower reaches are enlarged to accommodate the floods. The head of the Katjooree is at present enlarging more slowly than before, because of the restrictive action of a stiff knoll of clay at Chargurreah, but directly this clay bank, which is of small extent, is cut away, the head may extend till it is finally stopped by a low line of hills at some little distance inland. Lieutenant Harris points to the levels and tables to show that the velocity of the floods is greater from Naraj, for the first 6 and 9 miles respectively, in the Katjooree and Mahanuddy, than it is in any other portion of the river's course from Tickreeparah to the sea; and that the greatest depth of water and slope of sand exists at this debouchure of the river, and that this is the portion where the river has the greatest power, and must be placed under control.

32nd & 33rd Paragraphs.

10. I will not follow Lieutenant Harris in his enumerations of the laws which regulate the action of the rivers, in which he hinges upon the proposition of Gemiété, and discusses the effects of affluents on a main stream and the converse, and comes to the conclusion that he would not attempt lowering the water-line by cutting new channels, but that concentration of the waters in a Delta of light alluvial formation, rather than their distribution into a number of channels, conduces to the efficiency of the discharging medium, and that the alteration of general water-line caused by such concentration is not lasting in effect.

11. I concur with Lieutenant Harris in thinking that by directing the river down its own bed rather than into the Katjooree, we shall not raise the water-level in its own bed, but that the action will be to clear out the bed and provide a fuller section of water-way than it has at present. Both the beds of the Mahanuddy and of its original great off-shoot the Beropa are choked with sand-banks and sloping deposits, and the capacities of the main channels have decreased as the draught of the Katjooree has increased.

12. In the 53rd paragraph, Lieutenant Harris explains very clearly that with high velocities the surface of the water is not horizontal in its section, but is raised in the mid channel or on one side, as the run may be straight or curved, and that there is a path of greatest rise and depth in water

53rd Paragraph.

running with a high velocity ; and that the direction of this path depends on the centrifugal force which obtains in bodies moving quickly in curved lines, so that (55 paragraph) the local level of a flood, at any fixed point, is sensibly influenced by its position with reference to the path of the current which is the real direction of the river.

62nd Paragraph.

13. The Executive Engineer proceeds to apply the laws he has observed and explained to the description of the great flood in the Mahanuddy of 1855. He calculates the discharge of the flood at 1,800,000 cubic feet per second, calculated from sections taken in the upper portion of the river. He furnishes a Table showing the distribution of this flood into the river's branches below Cuttack, and assigns a velocity of 7 feet per second to the water during high floods, both in the Mahanuddy and Katjooree, passing Cuttack. 1,040,000 cubic feet of water per second passed down the Mahanuddy round Cuttack Point, of which 1,350,000 cubic feet passed off by the Beropa. 7,80,000 cubic feet passed down the Katjooree, of which again 2,65,000 cubic feet were taken off by the Kokai.

14. In this part of his Report, Lieutenant Harris has shown much acumen in correcting theory by facts, and reconciling the two by an examination into the circumstances which have produced the differences ; this creates a feeling of confidence in the figured results which he offers for consideration.

67th and following Paragraph.

The Executive Engineer next describes the position of the Town of Cuttack during the height of the inundation when 50,000 tons of water per second were bearing down upon it in two columns of nearly equal moment : the one sweeping past with a long path and a parallel course, comparatively but little to be dreaded ; the other bearing directly upon the revetment and rising 6 feet above the level of the waters passing down the Mahanuddy.

73rd Paragraph.

15. The earthen Embankments below the revetment, on both sides, were breached, and the Town was taken in rear by the back-waters of the floods. The flood on the Katjooree side topped in some places the revetment, and continuing to rise, was only kept out by building up sand-bags. There was an hourly rise of two inches, and all the sand bags were expended before the waters began to fall. Lieutenant Harris refers to Plates XXI.

and XXIV. and Table IV. as affording a full view of the danger to which the Town was exposed, and he states, that the flood was not a maximum in respect to volume, and that the additional evils of local rain, a south wind, and high spring tides, were not in operation during this last flood, and he thinks, that if all these unfavorable actions of weather should concur with a high flood that the destruction of the Town could not be prevented.

75th Paragraph.

16. Lieutenant Harris now comes to the remedy for the progressing evil. He traces the high local level of the flood on the Katjooree Revetment to the short path of the current from Naraj. The waters having cut away the original line of bank and changed the path of the current from a rectangular to a direct line, increasing greatly the volume that enters the Katjooree branch, giving it a higher velocity and making it attain the extra level due to the impingement and consequent heading up on the revetment wall.

77, 78, 79 and 80 Paragraphs.

17. The remedy is in artificially lengthening the path of the current, but Lieutenant Harris argues that as the existing disastrous conditions of the Mahanuddy and Katjooree have been produced gradually by nature, we must look to nature for assistance in bringing about a remedial condition of things, and be content to produce a gradual reformation little by little.

83rd & 85th Paragraphs.

18. It will facilitate a comprehension of the 85th and 86th paragraphs to state, that I had formed the opinion, that a complete weir should be constructed from Naraj to the revetment on the Mahanuddy side, and that Lieutenant Harris, whose plans are from the first original, contents himself with recommending the construction of a sunken spur or incomplete weir.

19. When Lieutenant Harris first described to me the great basin of the Mahanuddy into which he had entered after passing through the rocky gorge at Naraj, I addressed Lieutenant-Colonel Baird Smith, knowing that he had examined the river works of Madras, which chiefly consist of weirs; and asked for information and advice, stating that it appeared to me a spur from Naraj was required to direct the current of the Mahanuddy down its own branch. I also drew a line for a canal from the Mahanuddy basin through the Pooree District.

So great a work as a weir, 4 or 5 miles long, did not then seem to

me practicable, but Lieutenant-Colonel Smith's reply was so full of confidence, and his argument in favor of complete weirs so strong, whilst he was able to give examples of their construction on a large scale and to point out how successful they had been and what little effect they produced on flood conditions of a river, that I adopted the idea of a complete weir with confidence after reading his reply.

20. This letter as well as a manuscript copy of Lieutenant-Colonel Baird Smith's Report on the works of the Cavery and Coleroon Rivers which the Superintendent of Canals very kindly transmitted to me, were of course sent to Cuttack for the perusal of the Commissioner Mr. Samuells and of Lieutenant Harris, and on my last visit to Cuttack, we discussed the question of complete and imperfect weirs.

21. It appears that if the construction of a complete weir could be extended over a long term of years, and if the permanent well-being of the city were a prominent consideration, Lieutenant Harris would recommend its construction, but that, under existing circumstances, he advocates the carrying out of a plan of minor operations, the construction of a sunken spur or imperfect weir.

86th Paragraph.

22. I think, on the contrary, that if it were possible, the complete weir should be made in one season, and that although the safety of the Town is a great consideration, the permanent relief of the District of Pooree from inundation is a greater object, and one that authorizes the expenditure involved in the complete work.

23. I have no doubt that Lieutenant Harris, in his future reports embracing the effects of the Mahanuddy floods upon the Pooree and Cuttack Districts, will give every consideration to the argument in all its bearings. In his present report, he confines himself to the local effects of the flood upon the Town of Cuttack, but in recommending the adoption of the more complete plan, it is necessary for me to forestall the Executive Engineer by pointing out the interests of Government involved in this question of placing the Mahanuddy under control.

24. Lieutenant Harris's spur has a height of 21 feet in the deepest part of the channel and in high floods, will be submerged to the depth of 17 feet. The direction which the path of the current would assume over and turning such a spur when the waters are at their highest, is doubtful; he would, however, assist it by brushwood operations, estimated to cost between 1 and 2,000 Rupees.

90th Paragraph.

25. In the event of Lieutenant Harris's plan being carried out, I should propose that a parallel sunken line of break-waters, formed with brushwood and bamboos, with branches and leaves on, be formed on both sides of the spur, at about 30 feet from it, and stretching 150 feet beyond it, allowing this end portion to be swayed by the current.

88th and 92nd Paragraphs.

26. Lieutenant Harris calculates the expense of his spur at 1½ lakhs of Rupees, and it would be well, adding for special superintendence and the numerous contingencies likely to occur in carrying out so novel a work, as also to provide for the sunken break-waters, to call it 2 lakhs of Rupees.

93rd Paragraph.

27. Now the remissions in Pooree, calculated over eleven years, somewhat exceed 15,000 Rupees a year; the damage done to Embankments in Pooree by excessive floods or rather the probable annual expense of a fruitless endeavour to maintain the Embankments under the existing state of things, cannot be put down at a less figure than 15,000 Rupees, add renewing breaches in Revetment Wall, 3,000 Rupees, and for annual damage done to the Public Roads and Bridges in Pooree, 2,000 Rupees.

28. From this rough calculation, which assumes low figures, the annual loss to Government from the existing state of the Katjooree head is 35,000 Rupees, and deducting 5,000 Rupees a year for the expense of maintaining the spur, 30,000 Rupees is left, which at 5 per cent., the rate at which Government borrows money for Public Works, represents an outlay of 6 lakhs of Rupees; hence it is obvious on these considerations that if Lieutenant Harris's spur will effect the required results, the work should be at once undertaken, as a great saving to the State and a measure promising much future improvement in the Cuttack Districts.

29. Having gone through the Report, I shall now endeavour to supply a description of the Plates. Lieutenant Harris has here shown himself to be master of his work. He has considered the information wanting, the way in which this could best be supplied, and how to embody it in Plans, so as to set before others, in the clearest way, the facts obtained from the Survey operations he has conducted. The conception of the Survey and of the Plates illustrative of its results is really admirable.

30. Plate I. is a Survey, drawn on a large scale, of the Mahanuddy

from Bydessur to Cuttack, including the head of the Katjooree. On this plan are entered in *large figures*, the heights of the flood of 1855, which have been absolutely ascertained, and in smaller figures the heights attained by the waters in places where the level could not be so clearly discovered, as to be placed beyond doubt. These heights are taken from an assumed horizontal line 100 feet below the zero of the Katjooree Revetment Gauge. The dotted lines directly across the bed of the Mahanuddy,* of the Katjooree,† of the Kokai, and of the Beropa;‡ in this Plan indicate the places at which sections of the river beds have been taken, besides which, there are two other very important sections on a level from the Lalbagh, (where the Gauge in the Katjooree Revetment is cut in the perpendicular stone wall) through the Town to the wooden Post Gauge in the Mahanuddy at the back of Lieutenant Harris's house.

* Plates III. IV. V. VI. VII. IX. X. XI. XII. XIII. XVII.

† Plates XV. XVI. XVIII. XIX.

‡ Plate XX.

Plate XXI.

The other, a section from Naraj, obliquely across the bed of the Mahanuddy to Temple Island and Maunchessur, in the direction of the spur, proposed by Lieutenant Harris.

Plate XIV.

31. Plate IA. exhibits, in longitudinal section, the highest flood level, and the lowest depths of the bed and the hydraulic line of mean depth for the whole 37 miles from Bydessur to Cuttack; the water-line during March 1856 is given, and from Oostya to Cuttack the lowest points of the bed are given in continuous section. This is a very well-imagined sheet of sections, and shows the sudden falls in the river owing to the contractions of the width of the bed.

32. Plate II. compares the present state of the sands at the Katjooree head and the path of the current, with the same as exhibited in the Revenue Survey made in 1840. The Survey of 1855-56 has been made by Sergeant McMillan with great exactitude. The whole of it is the result of triangulation; and the original plan, which I saw in the Cuttack Office drawn by himself, does this young subordinate Officer in the Department great credit, both for the workman-like Survey made and the style in which it was plotted and drawn: it was a laborious piece of work, really well-performed.

33. Plate XXII. is an admirable section, showing the length of the Katjooree Revetment. The flood levels attained in 1834, 1854, and

1855. The low portions of the walls (shaded black) which were happily raised in 1855 before the flood occurred, the portions (shaded blue) which were topped by the flood, which was only kept out by building up sand-bags. The portions (red) which were out of water, and the wall submerged (lilac.)

The deepest line of bed in June, 1855, and the line in January, 1856, are shown; the silting up being due to the brushwood operations, judiciously carried out by Lieutenant Harris in 1855-56. The water level of April, 1856, is also shown in this happily-conceived and well-executed Plan. I must add that the brushwood works at present in operation have, up to the last advices received, done much more good, and are silting up the bed at the foot of the revetment in the portions most directly impinged upon.

34. Plate XXIII. is a remarkable Table showing the motions of the Mahanuddy waters in its two branches, the daily rises and falls being exhibited in continuous lines, the one coloured darker than the other. The parallelism is very remarkable, the level in the Katjooree being the lowest until the flood rises 4 feet above the zero of the Gauge in the Katjooree Revetment, when the level in the Katjooree tops and that in the Mahanuddy rises in an increasing proportion above it, as the flood level rises in the Mahanuddy; and when this falls, that in the Katjooree falls with an unequal rapidity. This is a cleverly drawn up comparison of flood-levels for every month of the year 1855, showing the rainy season levels with the greatest accuracy. These heights, being observed, are entered on the Plan for both channels.

35. Plate XXIV. is a Table showing the hourly rise and fall of the Katjooree River as observed at the Lalbagh Gauge from the 27th of July to the 3rd of August, embracing the whole period of the extraordinary flood of 1855. This Plan is very clearly drawn and it is a most satisfactory one.

36. Plate XXV. is a larger copy of the Survey of the sands made by Sergeant McMillan, and it shows the position of the incomplete weir proposed by Lieutenant Harris.

37. Plate XXVI. gives longitudinal and transverse Sections of the weir, showing the low and high water levels.

38. Having briefly indicated the heads of Lieutenant Harris's Report, and the nature of the information set forth in the Plans submitted, I will presume that it is made clear that an evil action of the

river has been allowed, progressively, to establish itself, threatening not only to sweep away the city of Cuttack, but to devastate, with inundations, the fertile and populous District which lies South of the Katjooree. As an illustration of this last effect, I enclose an Index Sheet of the course taken by the great flood of 1855, in the Pooree Districts, drawn by Mr. Raynor, who is in charge of the Embankments.

Plan B.

39. This Map and the Statement of the Collector, that the remissions of Revenue on account of the damage done by the flood will amount to upwards of 20,000 Rupees, will show the importance to the Pooree District, of regulating the discharge of the Mahanuddy by the Katjooree Channel. Although the flood of 1855 was 2 feet higher on the Lalbagh Gauge than the flood of 1854, the damage done in Pooree was more extensive in that year, and the remissions amounted to Rupees 50,000 and upwards.

40. There is yet another evil, in the progressive deterioration of the bed of the Mahanuddy in its course through the Delta, which, together with the bed of the Beropa, its first off shoot on the North side, is becoming choked with sand-banks.

41. The circumstances of the Delta of the Mahanuddy are somewhat similar to those of the Cavery Delta, which is watered by the Lower Cavery and the Coleroon channels.

Colonel D. Sim, in his Report on the Coleroon Anicuts, says, "Colonel Caldwell, who first examined the rivers with care in 1804, was forcibly struck with the unusual character of the Cavery, and predicted its total annihilation at some future period unless the river could be restored to what he believed to have been its original condition;" and again, "the catastrophe, foretold thirty-five years ago by Colonel Caldwell, our most experienced and judicious Civil Engineer, was becoming yearly more certain, and though no doubt distant, the evils resulting from the operations of its causes were constantly increasing, and becoming more injurious and more difficult to remedy."

42. Lieutenant-Colonel Baird Smith, in his Report on the same Delta, states that "In 1804, Captain Caldwell, of the Engineers, had arrived at the conclusion that if effective measures were not adopted to rectify, by artificial means, the natural differences between the two branches, the inevitable issue must be the annihilation of the Cavery as an irrigating stream, and, as a consequence thereof, the total ruin of Tanjore."

"For nearly twenty-five years from the time at which Colonel Caldwell's works were completed, an incessant struggle was maintained against the increasing tendency of the river bed to silt up. The head and many parts of the channel were periodically cleared of deposits by manual labor; long and expensive earthen Embankments were carried across the bed of the main stream so as to force a larger supply of water into the Cavery branch. All these efforts, however, were ineffectual; the bed continued to rise, the supply to diminish, the extent of land under irrigation yearly decreased, the Revenue was falling off, and the condition of the people was visibly becoming worse and worse. About 1829-30, the crisis had been reached, and at that time there began the series of operations of which the final issue has been the successful removal of all the evils complained of and the establishment of the relative conditions of the Cavery and Coleroon on an entirely satisfactory basis."

I am not aware that any warning voice was raised to point out the inevitable destruction of Cuttack and the ruin that must eventuate to its Districts from the operations of the Mahanuddy River, if it should be left to work out an alteration in its channels of discharge through the Delta. The matter has only now been seriously taken up, when the most unfavorable result has been attained by the complete abrasion of the river bank below Naraj, and when the highest rise and the deepest path of floods are established in the Katjooree channel.

43. The reason for such indifference to the progressive alterations in the Mahanuddy channels is obviously to be set down to the fact of the cultivation being carried on without any general plan of river-irrigation.

The agriculturists in Cuttack depend for water upon the local rain fall, and the consequence has been occasional famines, an awful occurrence in a Delta which has no communications by which food can be supplied to a starving people.

44. Colonel Sim, in the Report I have quoted from, observes that "lands which are cultivated from rivers, are generally the least liable to suffer from drought, for even when the Monsoon rains fail, there is always some water in rivers supplied by the drainage of the country and springs, and there are many rivers well-suited to the purpose, the waters of which now run waste to the sea."

45. The waters of the Mahanuddy have hitherto run waste to the sea, no one has particularly observed the operations in progress, the

beds filled with sand have caused continual action upon the banks and changes of direction in the currents, and river floods have burst the barriers and inundated the Districts; the sole care taken has been to reform the Embankments as they have been breached, and to keep the floods as much as possible in the river channels, without making any attempt to regulate the volume to be discharged by each.

46. If the people had depended generally upon the rivers for irrigation, the land-holders would have closely watched the changes unfavorable to them and through the Collector have called attention to the deficiency of the supply. However it may be, the fact is clear that nothing has been made of the Mahanuddy; that the river has been left to do its worst; that even where it would otherwise be navigable, rocks are left to obstruct the passage; that the Province has suffered most fearfully from famines, although it has the great advantage of a large trunk river winding with many branches through every part of it.

47. The produce of the land in the higher reaches cannot be conveyed to the Delta, and the mineral wealth of the hill districts has no outlet; with large volumes of water there is no navigable channel, and between inundations and drought, the country, with all its natural advantages, is continually subject to disasters.

48. Having referred to the Tanjore Rivers, I take advantage of Lieutenant-Colonel Baird Smith's kindness to embody, from his Chapter on the Delta of the Cavery, the results fairly established by the experience gained from these works constructed in that Province.

1*st*.—"That the waters of large rivers may be distributed between their branches and in proportions sufficiently exact for practical purposes by the use of dams at the points of separation, having their crowns at such heights as experience in each case may prove to be necessary. No general rule regulating these heights seems as yet to be possible, but as the field of observation extends, it may be arrived at hereafter."

2*nd*.—"That the influence of such dams, judiciously established, on the beds of the rivers in regulating the currents, in equalizing the distribution of deposits, and in maintaining the permanency of the sections of the beds, may be very beneficial."

3*rd*.—"That in rivers, with beds of pure sand and having slopes of 3½ feet per mile, such dams may be constructed and maintained at a moderate expense."

4*th*.—"That the elevation of the bed of the river above the dams

to the full height of the crowns of these works, is an inevitable consequence of their construction, and that no arrangement of under-sluices has as yet been effective to prevent this result."

5th.—"But that where effective escapes are provided in the banks of irrigating rivers (like the Cavery) the entire volumes of which are absorbed in irrigation, it is possible to prevent any injurious elevation of the bed by sand deposits."

6th.—"That in pure sand, acted on by the current due to a fall in the river bed of 3½ feet per mile, and exposed further to the action of floods from 12 to 15 feet deep, well-foundations, in front and rear, of 6 feet in depth, have been proved, by an experience of fifteen years, to be safe."

7th.—"That with a vertical fall in rear of the dam, from 5 to 7 feet in height, a thickness of 2 feet of brick masonry, and 1 foot of cut-stone, with a breadth of from 21 to 24 feet for the apron, have proved sufficient to insure stability, the only further protection required, being a mass of rough loose stones about 9 feet in width and 4 in depth. As a rough general rule it would seem that the masonry apron should have a thickness equal to ½, and a breadth between three and four times the vertical height of the bar forming the obstructive part of the dam. The loose stone apron should at first have a breadth equal to 1½ times, and a depth equal to two-thirds the height of the dam. The action at the tail of the work leading to constant additions to the loose stone soon deranges these proportions, and they are given only as guides in the first instance."

8th.—"That the main security of the dam depends upon the efficient construction and careful maintenance of the apron."

9th.—"That in freshes the dam speedily receives the protecting effect of a backwater on the apron; the surface level of the down-stream side being level with the crown of the work when the floods rise to 8 feet above ordinary low water, while beyond that depth the fall over the dam gradually diminishes till, in 16 feet floods, it has wholly disappeared and scarcely even a ripple on the surface indicates the existence of the mass of masonry below."

49. These are the engineering points deduced, but as the financial aspect of the works, as paying works of irrigation, is briefly summed up in two sentences, I also insert them, although not bearing directly on the subject under consideration.

10*th*.—"That looking to the cost of the works executed between 1836 and 1853, and the increased area of irrigation due to them, the capital sunk amounts only to 6½ Rupees or about 13 Shillings per acre."

11*th*.—"That after deducting every expense which the irrigation works of the Cavery have entailed on Government, the net returns may fairly be estimated at not less than 23½ per cent. on the invested capital."

50. But to return to the Mahanuddy and to the works proposed with the special object of training the floods down the original bed.

51. Lieutenant Harris's proposal is to place a dam across the ordinary channel which the river takes in its way to the Katjooree Revetment. He proposes to raise a mole, 21 feet above the lowest point in this channel, to form it with large pieces of rock, pitched into position, and taking their own set, and to form the mole, 20 feet wide at top, commencing from the stronghold at Naraj, making it a continuation of living rock.

52. The slopes will depend upon the size of the blocks of stone. In a break-water successfully formed in 1853-54, after a similar fashion in the Harbour of Port Elliott, South Australia, the stones setting by their own weight assumed a slope of about 2 horizontal to 1 vertical: but they were of enormous size: of 100 blocks—

50 contained from 60 to 90 cubic feet each.
25 contained from 30 to 60 cubic feet each.
25 contained smaller ones.

53. This break-water is exposed to the force of the sea and has a width at top of 21 feet and is raised 5 feet above high-water. It has stood some violent storms without the displacement of a stone, so we may conclude that the section of dam proposed by Lieutenant Harris would stand, provided the blocks of stone were large enough.

The break-water stands upon a reef, and the work in the Mahanuddy will be upon sand, and an apron must be constructed to the rear to receive the overflow. The brushwood sunken break-waters mentioned in my 25th paragraph will assist deposits and prevent the abrasion of sand round the spur.

54. The re-action from the sunken spur, during high floods, will cut away a good deal of the sands which at present protect the apex

of the Delta on the Katjooree side. The firm point at Chargurreah* will also be subjected to a violent abrasive action. The outlet channel† just below the heel of the spur, will prevent the back-water silting up the bed between the bank and the spur. There will be a greater action on the Katjooree side of the tongue, and the channel might lead more into the Kokai and less against the revetment than it does at present.

* Right bank of the Katjooree.

† This flows into the Kokai.

55. During low freshes and in the dry seasons the spur will completely direct the waters, and Lieutenant Harris, with brushwood operations, would take advantage of the direction given to the stream to continue it down the bed of the Mahanuddy, making it work channels through the sand-banks.

56. The re-action of the river in clearing the rock-bound channel at Naraj, has been the cause of the great increase to the head of the Katjooree, we may expect a similar re-action in a less degree after clearing the tail of the spur.

57. If the sunken spur be adopted, I think one of two greater works will be required; they are shown in the annexed Plan (A) G H, a continuous dam across the Katjooree bed between the stiff clay bank at Chargurreah and the stone revetment, where it turns towards the Mahanuddy. The section of the bed is favorable (Plate XV.), but the abrasive action on the tongue would be very great, and the Revetment, on the Cuttack side, is not a work to be depended upon. In this case we should have to strengthen the works round the exposed tongue of the Delta. The other work has few objections. It is a continuous dam, 14 feet high, across the Kokai outlet round the point of land and across the Katjooree bed.

58. It would be necessary to give sluices and a lock-gate to the weir in the Katjooree.

59. I think this last work might prove sufficient without the directing spur at Naraj. Common brushwood operations being adopted to clear out channels in the Mahanuddy, the bed of the Katjooree above the dam silting up and opposing the flow of water in this direction.

60. The dam in the Kokai would diminish the floods in the Pooree Districts, and I would here observe that, owing to the sand-banks, no water passes into the Kokai until the floods rise above 10 feet on the Lalbagh Gauge, and that if the barrier of sand were to be removed

without diminishing the flood in the Katjooree, the result would probably be the destruction of the Embankments of the Pooree Rivers to a great extent and the complete inundation of the District to the damage of the road-works, and private property and the destruction of crops resulting in a great loss of Government Revenue, a large outlay in repairs and much internal distress.

61. But the project I have held to since receiving Lieutenant-Colonel Baird Smith's letter, and the one I recommend for adoption (as per the accompanying rough Estimate) is a continuous weir across the head of the Katjooree connecting Naraj with the Mahanuddy by a curvilinear bank of rubble stone bedded in the sand, each stone pitched into position with clay and quarry rubbish to fill up the interstices and assist in making the mass solid. I must now solicit a re-perusal of my letters, No. 1138, dated 25th August, and No. 1439, dated 24th September, 1855, which will show that the views therein expressed are very much those now advocated.

62. Experience has shown that this description of work answers.

63. In Mairwarra where the foundations are generally rocky, the escape-weirs, some of which are of great magnitude, are regularly founded and built with lime cement. I give in the margin (A) sections of these works taken from Lieutenant-Colonel Dixon's Report on Mairwarra.

64. The best experience and what Lieutenant-Colonel Baird Smith calls "one eminently satisfactory result" has been gained from the old Anicut of the Cavery, which consists of a solid mass of rough stones of moderate size, 1,080 feet in length, from 40 to 60 feet in breadth, and from 15 to 18 feet high, stretching across the bed of the Cavery in a serpentine form. It appears that "when the under-sluices were to be constructed in 1830, it became necessary to cut through the body of the dam to a depth of 12 feet, and it was then ascertained, for the first time, that the stones of which it was composed were laid not in Hydraulic cement of any kind, but merely in clay; and it was accordingly clear that the old dam had effectually withstood the floods of 1600 years by the mere inertia of its materials. This proved a most encouraging discovery, for it was legitimately argued, that if a work of such dimensions composed only of rough stone and clay, could control the river at all periods, it was clearly possible to construct another in which the resources of European skill could be employed to reduce the

dimensions by the use of superior materials, and thus to bring the cost within such limits as would fully justify the Government in undertaking it."

65. In the present case rough stone is the cheapest material we can employ; and to work with more perfect materials, reducing the dimensions, would only be to increase greatly the expenditure; moreover, in a bed of sand, there is much virtue in weight, which gives the mass resisting power, and compresses the substratum, making the sand bottom comparatively firm.

66. Colonel DeHaviland, writing of the Madras break-water, which was constructed dry with rubble blocks of stone, each taking its own set observes—

"There is a great advantage in this way of proceeding, that however the work may suffer, from time to time, it can only become more consistent and secure; it must in the end, bring the work, if persevered in, to its intended use and effect."

67. I take for granted, that there is no reason for want of confidence in the stability of the works now proposed, and that no uneasiness will exist on this score. The examples I have cited are sufficient to guarantee the eventual success of a continuous weir formed with blocks of stone, across the head of the Katjooree, over which, high floods will spill, and along which, the waters will flow, until they cross to the deep channel which will form along the left bank of the Mahanuddy, and not round the tongue and down the revetted side of the river.

68. The Beropa will be cleared and again become a river, and Lieutenant Harris is of opinion that this will be the best channel to make navigable, leading, as it does, to the Dhamrah. The Executive Engineer's attention will be specially given to the improvement of the lowest reach and to the mouth of the Mahanuddy to open a wider channel, so that the sand-banks and obstructions in the bed may be more easily passed off into the sea; and I see no reason to apprehend that the flood-rise of the Mahanuddy will be increased by the action of the weir recommended. I would make no sluices in the first instance, but carry out the work as a simple bar.

69. Finally, I would request that sanction be given to our collecting stone material and stacking it in the line of this weir in the section specified in the accompanying rough Estimate, removing sand for the purpose where it passes over the raised dry bed and pitching in earth,

quarry rubbish, and chips, with the blocks of stone to fill up the spaces between them. If with the earth we introduce the seeds of Doob grass and of some strong hardy creepers, the effect will, I think, be to bind the mass with a net-work of natural cordage, the creepers taking a fresh start from between the loose stones where their long arms would enter and take root.

70. In this way the sand barriers along the Hidgelee shore are naturally strengthened; the loose sandy surface is first run over by a thin but strong creeper, which keeps the sand firm even on the steep side facing the sea; and wherever the slopes will admit of it, the growth of grass follows that of the creeper, and the hillock becomes comparatively a permanent barrier, refreshingly green on the top and land side, and trellised on the sea-face with wax-like leaves and purple bells, the roots and branches of which bind together the dry sands heaped up by the wind.

71. This weir will not be similarly circumstanced with the Madras river works. Advantage is taken of a narrow channel, with a rocky bank, to continue with a gradual opening, the obstruction to the lateral spreading of the waters; the direction of the floods will be continued and not opposed; instead of sand being heaped on the upside of the weir, there will be a scouring action along the foot, for a considerable portion of its length; instead of stretching across the bed of the river, and being perpendicular to its banks as the Madras Anicuts are, it is on the contrary a formation of an artificial bank in the general direction of its own bank, shutting up an outlet, and forming in high floods an overfall. Below the sill of the dam the waters will have the onward motion due to the river restrained in its lateral action; above the sill, the waters will rush over the dam, into the lower level—there will consequently be an under current in the direction of the Mahanuddy side of Cuttack and a spill into the Katjooree channel.

72. Two pertinent questions may here be asked—

(I.) Are the lower channels of the Mahanuddy and its branches capable of bearing the increased volume that will be passed off on the Mahanuddy side of Cuttack, and will not the flood level in these channels be dangerously raised?

(II.) Will not the villagers along the banks of the Katjooree and its branches suffer from the withdrawal of the constant dry weather stream that at present discharges through them?

73. In reply I must state, that the information is not yet complete; that Lieutenant Harris's Report is only Part I. of the subject under investigation. In the absence of facts, I must give opinions.

74. The works projected have one single object; to restore the equilibrium of the channels by clearing out the raised bed of the Mahanuddy, reducing the discharge by the Katjooree, and causing the Beropa outlet to resume its original importance as a channel of relief.

75. But the flood-rise is much higher than ought to be allowed, and it is to be hoped that some large reservoirs may be formed, at moderate expense, in the hills above the Delta, so that the flood waters may be stored till the dry season, and then returned to the river bed for the maintenance of a navigable fair weather channel.

76. It is my opinion, that the state of affairs, during high floods in Central Cuttack, will not be worse than at present, and that in South Cuttack (Pooree) there will be considerably less danger of inundation.

77. In the dry season, and this answers question (2), I do not think that there will be any very great difference in the streams through the Pooree District. In fact the Pooree Rivers have no stream running into them.

78. The outlet below Naraj is quite dry* and choked with sands deposited by the eddying back-water. The Kokai has a high bar of sand across its head, but in the Bargony and Daib Rivers, which are formed by the bifurcation of the Kokai, there are running streamlets. At a certain depth, below the sand, there is water, and at a certain level below the fountain head, this water makes its appearance and flows, and in this way I expect the water in the Katjooree channels will not be greatly diminished; but if it is, a dry weather weir can be made lower down to raise the level, and sluices can be opened in the dam to increase the supply.

Barung Nuddy.

Before closing this letter, I would advert to the proceedings of the Committee appointed to report on the Cuttack revetment after the rains of 1848, of which Lieutenant-Colonel Sage was President. To the Report and Estimate submitted by Lieutenant-Colonel Goodwyn, Superintendent Engineer, South-Eastern Provinces, for the re-construction of the revetment on the Katjooree side, and also to an Estimate which, if my memory is correct, was framed by the late Colonel Forbes* for the same purpose, as showing the interests at stake in the

* This may have been framed by Colonel Forbes as a member of the Military Board. In 1847-48, there were many proceedings on the subject of the Cuttack revetment.

town and station of Cuttack and the expenditure involved in all the plans that have been brought forward for the protection of the place.

79. These plans did nothing for the rivers, and left the districts to their fate, as threatened by the present bias of the Mahanuddy.

80. To increase the interest in this matter and also to afford information, I enclose three sheets of pen and ink Drawings.

No. I. illustrating the Cuttack Revetment and the style of the old Mahratta works in the Pooree district.

No. II. a view taken from a projecting ledge of rock in the hill above Naraj looking towards the point of bifurcation.

No. III. a view from the low hill at Naraj looking up the gorge.

See Specifications.

81. The Memorandum* drawn up to accompany the two rough Estimates enclosed, states all else that I have to say at present.

It is not out of place, when calling attention to the necessity for a large expenditure, to bring forward facts stated, and opinions placed upon record, which exemplify fully the interests at stake in this Province; and I purpose to close my Report with extracts that must have weight in determining whether the Mahanuddy is to be left to itself or to be placed under control, whether it is to be the evil genius of the country, or to be made the source of its future prosperity.

Inundation.

82. In 1834-35 the country was laid waste by inundation, and Rupees 1,86,942 of the Revenue was remitted.

Famine.

In 1836-37 a severe drought desolated the Province, and Rupees 4,52,532 were remitted.

Famine.

In 1837-38 a similar calamity occurred, causing a remission of Rupees 5,87,146.

Famine.

In 1840-41, in the Cuttack Collectorate only, the remission from want of water and failure of

Drought.

the harvests amounted to 3,73,107, and in 1841-42, from the same reasons, there was a

Drought.

further remission of 2,09,290 Rupees and in 1842-43, from the same cause, an early cessation of the periodical rains, Rupees 4,86,625 of the Revenue of the whole Province was remitted—nearly 23 (twenty-three) lakhs of Rupees in nine years!

83. The above remissions were made before the present settle-

ment, and Commissioner A. J. Moffat Mills was of opinion that "under the just and liberal terms of the present settlement, the Zemindars may fairly be expected to bear ordinary losses." The above remissions were not for ordinary losses, and the same excellent authority said that the settlements cannot stand the "test of all seasons, Cuttack being a Province which is confessedly subject, as the Court of Directors write, to seasons of extreme uncertainty; and liable to the most remarkable vicissitudes of drought and inundation."

84. I learn that losses are considered ordinary in Central Cuttack when they do not exceed one-fourth of the produce. The Revenue received from Central Cuttack, under the present Settlement, is 7,19,343 Rupees, and from the Tributary Estates 1,01,576 Rupees.

85. In the Pooree District, or Southern Cuttack, the circumstances are widely different; the greater part of the Estates, almost all those exposed to inundations, are held (khas) under the direct management of the Collector, who realizes the Revenue from the ryots, who are entirely dependent on the crops for their ability to pay the rents, and partial remissions have to be made wherever the produce is destroyed, according to the partial damage sustained. We accordingly find that the sums entered below have been remitted of recent years in Pooree, whilst no remissions have been made in Central Cuttack.

86. The present sudder jumma of Pooree is 4,69,278 Rupees, and more than one-half of the District is uncultivated (4,48,497 acres cultivated, 4,68,532 acres uncultivated) which might be remedied perhaps, and the Revenue nearly doubled if effective measures were undertaken to rescue the Province from the evils of inundation and of drought.

87. The advantages of introducing irrigation from the rivers were understood by Mr. Mills, as appears from the following extract:— "Sluices in the Bunds afford the greatest facilities for irrigation, and therefore tend greatly to ameliorate the disastrous effects of drought. I represented to Government that the Zemindars would not bear half of the expense which the Government required as the condition of constructing sluices, because of the costliness of the works, and the small profits of their estates, and urged the policy of Government bearing the whole expense, on the grounds that it would diminish the liability to loss from drought and thereby benefit the State. This boon has been granted, the utility of the sluices only requires to be more known to be better appreciated."

88. I am not aware, however, that at the close of the rainy season, the people apply temporary measures to raise the water level and stop the flow of the rivers into the sea and Salt Water Lake, or in fact that any exertion is made to increase the produce.

89. I shall close this very lengthy document with a last extract from Mr. Moffat Mills's Minute, dated 23rd January, 1847, as it shows that this able Commissioner was of opinion that to preserve the town and station of Cuttack alone, it would be worth the while of Government to expend 3,90,595 Rupees in the reconstruction of the revetment on the Katjooree side, a measure that would produce no benefit whatever to the districts, nor help one jot to retard the destructive operations of the Mahanuddy; but the works now proposed, whilst they have for their object the maintenance of the main line as the principal channel of discharge, will, by restoring the equilibrium of the rivers, make the existing revetment a protective work, and supersede the necessity for reconstructing it.

"The Cuttack revetment has this year* given way in several places, and I understand that its restoration will cost not less than 3,90,595 Rupees. The Mahanuddy river, which is said to rise near Bustar, enters the plains at the station of Cuttack, throwing off its tributary, the Katjooree, to the south of the town. In the rains the torrents descend with fearful rapidity, and to protect the town from inundation on the southward; this solid embankment was constructed by the Mogul Government in the reign of Jahangeer 225 years† ago, and has been always kept in repair by our Government. Stirling says, 'It yielded in places, in the memory of man, and the consequences were tremendous.' Fortunately in the last season the waters timely subsided and no mischief was done. The amount of the estimate is large, and the value of the Government property at the station is not of that extent as would justify the restoration of the embankment. It would be cheaper to establish the station at some other place, but the question depends on other considerations, viz. the value of the city, intrinsically and commercially. The existence of the town depends on the continuance of the revetment. Cuttack contains a population of about 50,000 persons; there are about 6,300 houses, of which $\frac{1}{6}$ are pucka, many of them built of stone, (amongst them that fine mansion, the

* 1847.

† This must be the modern wall rebuilt on the Katjooree side.

'Lalbagh' which is built on the revetment.) The city is situated on a tongue of land at the bifurcation of the Mahanuddy and on the high road to Ganjam; it affords convenience for carrying on a commerce with Sumbulpoor to the West, Madras to the South, and the low countries to the East, while its proximity to the Hills points it out, in a political point of view, as the most desirable place for the cantoning of Troops. I am of opinion that the restoration of the revetment is a work of too great public advantage to be weighed by considerations of expense only, and would, therefore, earnestly recommend that it be re-built."

P. S.—I would remark that Captain Short, late Officiating Executive Engineer of Cuttack, submitted to you a memorandum dated 15th February, 1855, in reply to Chief Engineer's No. 1478, of the 22nd of August, 1854, in which he clearly stated the evil working of the Mahanuddy in enlarging the head of the Katjooree, and expressed his views generally.

Mr. Samuells also, as Commissioner, addressed the Board of Revenue on the subject of the inundations of the Pooree District, and suggested the construction of a weir across the head of the Kokai. Revenue Board's No. 320, dated the 13th October, 1854. Chief Engineer's No. 2467, of the 4th November, 1854.

No. 2. PROJECT.

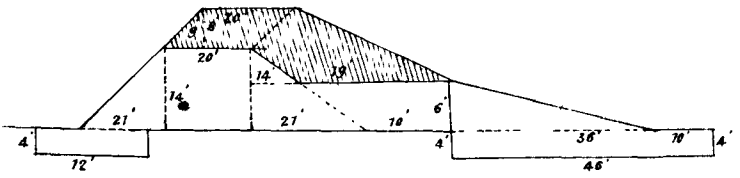
Rough Estimate of the Expenditure of forming a continuous Weir across the head of the Kokai and the bed of the Katjooree Rivers of rubble stone dry masonry.

IN the event of the continuous weir across the head of the Katjooree being considered too expensive for adoption, it may be well to consider what the effect would be of constructing a weir across the bed of the Katjooree below the revetment wall taking in the head of the Kokai river. The object of constructing such a work would be to silt up the Katjooree's bed to a height that would force the waters down the Mahanuddy Channel by making that the lowest bed. The Katjooree would silt up to the sill of the weir, and this operation would be like tilting up the present channel which draws away so much of the waters. The revetment would be imbedded with sand and thereby made secure. The Kokai would have an effective permanent barrier to check the early

entrance of floods instead of the present insecure one of sand, which was greatly diminished by the flood of 1855, and will have been still more so by the flood of this year which lasted a long time and rose to a greater height in the Pooree Rivers than has been the case before.

If the three great advantages above described, can be secured by the works I am now bringing under notice, then they are to be preferred to the longer weir first proposed and recommended by me as the safest and most certain work. At present the level of the waters in the Mahanuddy exceeds that in the Katjooree until the rise is 3 feet above the zero of Lalbagh Gauge above which the level of the waters in the Katjooree tops that of the Mahanuddy stream. The dam below the revetment would raise the level of the water in the Katjooree, which would at first be a reservoir to the Mahanuddy and afterwards form a wide funnel-shaped overfall with two outlets.

The question is, what height of overfall is required. The water channel is deep and not very broad; the dry bed is high. I would first try 14 feet, which will stem the flow of the dry weather current. I would give the same height to the Kokai dam; but this will place the sill of the Kokai weir at least 10 feet above that of the Katjooree dam. The expense must be estimated at a higher rate than for the weir from Naraj, the distance the stones have to be conveyed being greater. I cannot fix the rate at less than 4 Rupees the 100 cubic feet for the construction of the dams; the section on the opposite side has 1,001 square feet, and the length of the Katjooree weir will be 3,500 feet and of the Kokai weir 2,500 feet; 3 furlongs of river bank will require to be protected. The brushwood operations at the head of the Katjooree and mouth of the Mahanuddy will be extensive, and the construction of under-sluices may be necessary in the Katjooree, although I do not recommend their being constructed at first.



$14 \times 20 = 280$
$2 \times 14 \times \frac{21}{2} = 294$
$4 \times 12 = 48$
$\frac{6 \times 29 \times 10}{20} = 87$
$6 \times \frac{36}{2} = 108$
$46 \times 4 = 184$

} Calculation of Section.

1,001 Square feet in Section.

1,001 × (3,500 + 2,500) = 60,06,000 cubic feet in the two weirs.

60,06,000 cubic feet at 4 Rupees per 100 = Rupees 2,40,240

Protecting banks 3 furlongs, brushwood operations at the head of the Katjooree and at the mouth of the Mahanuddy constructing under-sluices in the Katjooree weir and contingencies, ... 59,760

And adding the shaded section to the Katjooree weir when the first section shall have settled so as to form an additional height of 6 feet to the dam, which will afford a good roadway across the river.

$\frac{20 + 63}{2} \times 14 = 581$
Deduct $\frac{20 + 44}{2} \times 8 = 256$
325

325 square feet × 3,500 × 4 Rs. Rupees 45,500

Total 3,45,500

Rupees, or say 3½ lakhs of Rupees, and by this work a dry causeway will be afforded for the passage of the traffic between Cuttack and Pooree—a desideratum and a convenience that might fairly be taxed.

The old native Anicut over the Cavery bed has been made use of as a road, and a bridge has been erected upon it as upon a secure foundation, although like the weir now proposed it is formed of rubble stone and is dry masonry.

J. P. BEADLE,

25th August, 1856. *Supdt. of Embankments.*

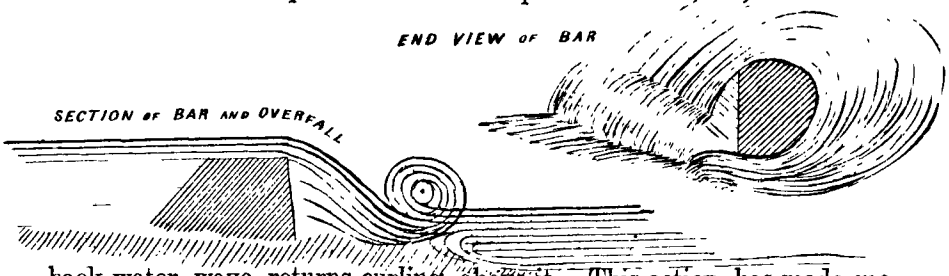
PROJECT 1.

Estimate for the construction of a Dry Stone Weir to commence from the Rock at Naraj and to stretch across the head of the Katjooree in the line of the Mahanuddy's left bank.

SPECIFICATION.

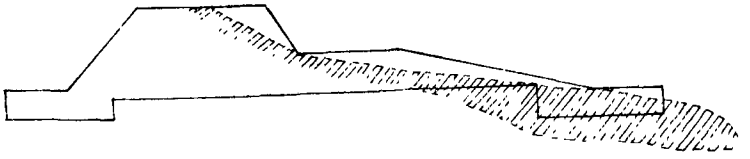
Lieutenant Harris's estimate for the construction of a sunken spur, to commence at Naraj and to extend for nearly one mile directed upon the Temple Island, is contained in the 90th and three following paragraphs of his Report. From the Plate (XXVI.) and this estimate, it appears that he contemplates carrying out the spur on the existing section of the sand instead of constructing it on a base level with the lowest depth of water, which I consider to be necessary for the pooling round the spur, as the length progresses would carry away the sand at the head, and in the continuous weir, I am now estimating, for I purpose the section of the weir to be the same throughout the length, which is 4½ miles.

I have observed, that the fall of water over a bar is invariably attended with a deep indented hollow parallel to the bar, and that a



back-water wave returns curling above it. This action has made me consider the form of section best adapted for passing the waters quietly from the overfall of the dam.

The action round a sunken spur is shown in Figure 2, and it is easy to perceive, directly one makes the experiment in running water, what a hollow eddy works round the head of a bar which has its end in the stream and what very much less commotion is caused by a continuous weir.



The section I submit for consideration, will, I think, in course of time, become a very good shape, as shown in the dotted line.

Lieutenant Harris does not estimate for an apron, but allows 50 per cent. for sinkages and re-construction until the mass shall have acquired a firm seat. I propose to make front and rear curtains as well as an apron. I do not think that the sill of the weir need be made 21 feet high, and I have adopted 12 feet as a sufficient height, but this is an uniform height, whereas Lieutenant Harris's is an extreme height where the water is deepest. The work should be carried out from the Naraj end, and I expect that the path of the current deflected by the portion constructed, will cut away in front of the length done and excavate the sand for the continuation of the weir at a proper depth. The blocks of stone should be of the largest size that the means of carriage will admit of our conveying. The weir should be commenced with the smaller pieces of rock, the heaviest blocks being placed above and in rear. I have attempted, in the shaded section, to give an idea of the way in which I think the stones should be arranged, so far as the arrangement of them can be carried out without incurring additional expenditure, which, perhaps, is as much as to say that I would not attempt any arrangement at all, but leave the position of the stones to the set they assume of themselves. I would throw in sand and earth and quarry chips, so that there may be something for the stones to bed in or rather to fill up their interstices. As the banks above Naraj are of rock and there is water-carriage to and along the proposed weir and labor is cheap in Cuttack, I hope that Lieutenant Harris will be able to execute the work, making arrangements on a grand scale for the rate he has assumed of Rupees 2-8 per 100 cubic feet of weir.

The continuous weir at this rate will cost according to the section. See the calculations on the Plan.

17,582,400 cubic feet at ..... Rupees 2-8 =	4,39,560	Rupees.
Add for establishment and contingencies at 10 per cent.	43,956	„
Add for works protective to the head of the Delta and for brushwood operations at the mouth of the river near False Point, ...	16,484	„
Total, Co.'s Rs.	5,00,000	

I do not think I can conscientiously say, that the work is likely to cost, first and last, less than 6 lakhs of Rupees, which is the amount at which I am prepared to estimate the expenditure Government is likely to incur, if my recommendation for the construction of the continuous stone over-fall bank across the Katjooree outlet is acted upon.

It will afterwards be found to be advantageous I think, if the height at the Naraj end, the beginning of the weir, is increased considerably, and the top surface sloped down for about half a mile of the length of the weir.

J. P. BEADLE,
Supdt. of Embankments.

21*st August*, 1856.

REPORT upon the Extraordinary Flood of the Mahanuddy River and its branch, the Katjooree, during the rainy season of A. D. 1855, *considered with reference to local effect upon the Town of Cuttack, being an inquiry into the probable past and actual present Flood Conditions, the measure of danger to the Town, the Cause and Remedy. By* JOHN C. HARRIS, LIEUTENANT, BENGAL ENGINEERS; *dated Cuttack, 5th June,* 1855.

Sir Charles Lyell, in his first Chapter upon "the Principles of Geology," remarks, that "to acquire a perfect knowledge of the present conditions of the earth, and form a comprehensive view of laws governing it, we must search into its state, at former periods, and trace the long series of events which have gradually led to actual posture of affairs. The historian and geologist, (he says), will rarely fail to draw correct and philosophical conclusions from the various monuments transmitted to them of former occurrences. They know to what combinations of analogous causes, effects are referable, and are often enabled to supply by inference, information concerning many events unrecorded in the defective archives of former ages."

2. The soundness of the above maxims one cannot fail to recognise, nor again the universality of their application in every branch of science. I propose in consequence opening the present inquiry, with a consideration of what the historian has recorded, or even tradition asserts bearing upon the subject of the past conditions of Cuttack, a knowledge of which would appear as necessary to the recognition of

the instability of present conditions, as to the formation of a tolerably correct judgment even upon the remedial measures demanded to ensure a favorable future. I will give then

A BRIEF ACCOUNT OF THE ORIGIN OF THE TOWN OF CUTTACK.

3. "Rajah Nirupa Kisseree (says Stirling) a martial and ambitious prince, who was always fighting with his neighbours, first planted a city on the site of the modern Cuttack about A. D. 989. His reign was distinguished for the construction of a stone revetment or embankment faced with that material (probably the ancient one of which the remains are to be seen) to protect the new capital from inundation A. D. 1006. Also that Rajah Aurung Bhim Deo, one of the most illustrious of the Ganga Vausa line, ascended the throne of the Gajapatis in A. D. 1174, and induced by some omen* built a magnificent palace on the site of Fort Barabuttee, adjoining the town of Cuttack. The construction of the present castle of that name should, in all probability, be referred to this period, though a later date is generally assigned to it."

4. It would appear from the above, that the construction of the three works named above was effected in the following order, and at or about the period shown below:—

1*st*.—City of Cuttack..... A. D. 989.
2*nd*.—Revetment..... A. D. 1006.
3*rd*.—Barabuttee Fort..... A. D. 1174.

5. The popular tradition on this subject, as far as I have been enabled to acquaint myself thereof, ascribes the construction of the revetment or "Murra Tandia Bund"† to a period posterior to that of

* The current story, as to the origin of either fort or town alike, is to the effect that the builder struck on a falconing expedition over this part of the country with the prowess of a "boglah" (or paddy bird) in repelling the strike of his favorite hawk, selected the site for his works to the rejection of another on the opposite bank of the river where they had already been commenced, deeming the soil on which the boglah was reared to have some peculiar virtue inherent.

† Saddhoo Routh, a poor villager of Kodinda, Bukrabad, is said to have provided the funds for the construction of the "Corpse Taxer's Revetment" (as the name implies *Murra* "corpse," *tands* "tax"), under the following circumstances:—Sent by his wife into Cuttack to sell 12 pumkins, he was not only deprived by the soldiery on duty at the Barabuttee Fort Gate of the fruit, but the very bamboo on which he carried them, and, failing to obtain access to the royal person for the purpose of seeking redress, bethought himself of the subjoined expedient. Borrowing money for the purpose from his washerman, and hiring therewith attendants and rich attire, he paid Cuttack a second visit, proclaiming on this occasion his appointment as Corpse Taxer to the State, demanding payment at the rate of 10 Rupees per corpse ere he allowed the rites, funeral, to be performed. For ten years and upwards he is said to have plied his trade successfully, until a member of the

either of the other two works named, whilst the existence of the latter, depending as it does in these days so entirely upon that of the protective work, one would think the period of its construction, if not anterior to or coeval with that of the town or fort (whichever may have been first constructed) could not have followed at any very distant date, unless the conditions of the Mahanuddy river and its branches were widely different in those days than those which now obtain.

6. Tradition again affirms and probabilities go far, in my opinion, to confirm the fact of an alteration, the most extensive having taken place in the dimensions of the Mahanuddy and its branches.

7. The Mahanuddy (*Maha* "great," *nuddee* "river") is represented to have been ever the great *par excellence*, next in succession to have ranked the Beropa Nuddy, entitled also to the designation of a "river;" and, be it remarked, the only branch that was so. The Kajooree or Katjooree, (from khat, a log; joor, a small nullah), is said to have been, but when, it is not known exactly, an insignificant nullah crossed by a single log of wood, and to complete the category of the various branches of the Mahanuddy, I have only to mention the Khoakye (*khoa*, "a crow," *khye* "a hollow,") reported to have been a hollow in which the crows of the neighbourhood found the sufficiency of water to enable them to dip their beaks there with advantage.

8. Without all other, I must take the evidence of nature as to the then characteristic features of the tongue of land between the Mahanuddy and Katjooree, on which our town was built in bygone days. It seems to me desirable that what they probably were should be considered. The site must have been, at the period to which I refer, such as what it would be now (*i. e.*, flood conditions, as at present,) but for the existence of the revetment wall and its embankments, inundated by high floods, in all, by moderate ones, in many parts, the habitat of the "boglah" in fact. Though in these days, there may be dug up in Cuttack what has the appearance of a red gravelly soil, and

royal household dying, his plot was brought to the desired conclusion. On his demanding 1,000 Rupees ere he allowed the customary rites to be proceeded with (no Hindoo is allowed by his religion to taste food until he has disposed of the corpse of a relative) the presumptuous, self-appointed tax-gatherer was, as a matter of course, taken into the royal presence, and explanation followed. After commenting on the conduct of princes in general, and the reigning one in particular in denying themselves to the very poorest of their subjects, the quondam Corpse Taxer retired into private life, giving up the whole of his illicitly-gained wealth for the purpose of constructing the Cuttack revetment, which work, it is said, was completed in five years. The width of the Katjooree at the time is said to have been (150 haths) 75 yards broad.

again mounds of the same material crop out from the low level of the site, it requires little stretch of the imagination to conceive it foreign broken laterite, (red and highly ferruginous) of which the Mahanuddy's bank immediately opposite the town is so prolific, brought to where it is now found for purposes to which the native light alluvial soil was unadapted.

9. In matters of level of site, and soil characterising it, I cannot err widely in estimating the state of things 8½ centuries ago to have been to all intents and purposes what it is this day.

10. Other, but relative, conditions may, nay must, have changed considerably during this long interval of time. In every portion of our globe do we see change in progress, beyond the power of human labour to produce; most especially where Nature's grand agent, water, is employed, can the working of her hand be traced in furtherance of designs, some so vast as perfectly to baffle understanding, but for our conception of the time and power at command being infinite alike. That design is fact, that execution is steadily progressive, is allowed on all hands, and I am inclined in consequence to look for changes wrought by nature, having nullified advantages once possessed by the site of which I treat rather than to condemn as highly injudicious the selection made by the founder of Cuttack.

11. To weigh each item of the above evidence and attempt to fix with precision the period of construction of any of the works I have mentioned, by whom or under what other than general circumstances they may have been constructed, would in no way forward my present object,—that of preparing the reader of this Report to allow the inferences I draw, and subscribe to opinions based thereon to some extent, which I shall have occasion to advance in the course of this inquiry.

12. I infer as follows :—

1*st.*—That the period since the construction of the city and revetment is measurable by centuries, these probably numbering 8½.

2*nd.*—That the flood conditions of the Mahanuddy and its branches were at the distant period named materially different from what they are in these days, involving change, a purely relative one, in the then conditions of the site on which Cuttack now stands: that the site is, in fact, the same *in ipso*, as it then was, and not so *in re*.

3*rd.*—That in the relation of the site to the Katjooree river is found the prominent feature of the change inferred.

13. To how remote a date we must look back for the existence of the Katjooree in such a state of insignificance that it was crossed by a single log of wood, it were useless to speculate upon, still more to do so upon the time when this branch of the great stream was non-existent altogether, when the line of the Mahanuddy's right bank ran direct from Naraj to Toolseepore. Non-existent this branch must have been, and this fact recognised, no more difficulty will be experienced in crediting the intermediate stage in which I infer matters to have been 850 years ago, than the encroachment of the Katjooree to the extent of one-third of a mile shown to have taken place in fifteen years in Pl. II. accompanying this Report, or again in sharing my belief as to the probable nature and extent of the river's future conquests. But I am dealing with the past not the future. Let me revert to past conquests of the river, and all collateral proof thereof I may be able to adduce.

14. To what then, but the operation of a process of enlargement at the head of the Katjooree, can, by any possibility, be attributed the tadpole-like disproportion between its head and limbs? To what again, the absence of ill-results, attendant upon the state of disrepair into which the revetment on the Mahanuddy side has been allowed to fall, and the reverse of this on the side exposed to the action of the Katjooree's waters? To what the necessity of entirely re-constructing a moiety of the protective works on the side last named which I find recorded on a stone to have been done in A. D. a fact of which we have ample evidence, besides (though not chronological) in the difference of character of the old and new works and even of the nature and size of the material employed.

15. All evidence that I can obtain from history, tradition, and from nature, is in favour of the supposition that the Katjooree's breadth has increased amazingly in size since the period of the foundation of Cuttack. The measure of the change is indeterminate, as is the period it has occupied nature in effecting it; but, as the mind can comprehend the lapse of time, so can the change be comprehended to have taken place. The Katjooree has doubtless sprung from nothing, originally risen from insignificance within the space of a few centuries. Such is my belief; such, I trust, will be found that of all interested in my theme.

16. I have now trodden the dark road of the possible past, sufficiently to render the study of the actual present and probable future of Cuttack a profitable one, and will proceed to give such general descrip-

tion of the town and its protective works, as is necessary to a correct apprehension of the local effects of the extraordinary inundation of A. D. 1855, which I had the fortune to witness and hope to be able to record on all important points. I subjoin—

A BRIEF ACCOUNT OF MODERN CUTTACK AND ITS PROTECTIVE WORKS.

17. Cuttack* is situated in Lat. N. 20° 28′ 45″ and Long. E. 85° 50′ 50″—5 miles below the apex of the Delta of the Mahanuddy river, which bursting through the narrow gorge between the Sydessur and Dawakote Hills, near the village of Naraj, debouches upon the alluvial plains of Orissa Proper, widening its bed out to an extent of between 2 and 3 miles preparatory to throwing off its main arm, the Katjooree, to pass the town on the south side, whilst it continues its own course to the eastward, past the north face of the Peninsula formed by this first grand division of its waters.

18. The site of the town is low, as will have been conceived from an earlier portion of this Report; and, as may be seen from Pl. XXI., showing the level of one of its principal roads to be in parts 7 feet below the incline of 3 feet per mile, connecting the flood-levels of the season A. D. 1855 of the Mahanuddy and Katjooree, and the town is protected from inundation by the revetment wall facing either river, connected at their ends by earthen embankments. I say protected from inundation, speaking of the means used; far from intending to signify the efficiency of those means, which, however, I will endeavour to describe as I find them, preparatory to allowing the protective works to merge into the part and parcel of the city itself, which I shall henceforth treat them as, in the same way as I propose, on the other hand, considering henceforth the Kâtjooree's arm of the Mahanuddy as a river, independent of its parent stream. I will give here—

* The real etymology of the word Cuttack is "Kâtâk," signifying, in Sanscrit, a royal residence or seat of empire. It was one of the five Kataks or capitals of Gangeswara Deo, the second prince of the Gang Ban's line, and is still distinguished by the natives as "Katak Biranasi" or Benares, by which name it is mentioned in Ferishta's History of Bengal and in the Ayeen Akbaree. The denomination "Biranasi," however, has been in latter times confined mostly to a village or patera which stands near the point of separation of the Mahanuddy and Katjooree rivers, about 4 miles distant from the town. Authorities vary as to the date of the foundation of Katak Biranasi, but there seems good reason to think that it became a capital city as early as the end of the tenth century during the reign of the Kesaree princes.—*Stirling's Account of Orissa.*

A GENERAL DESCRIPTION OF THE CUTTACK PROTECTIVE WORKS.

19. The revetment may be described as an irregular line of masonry, partaking of the character of a wall in some portions, of a simple casing in others, constructed of large blocks of laterite and sandstone, set in mud cement, and painted with lime plaster exteriorly, the weight of its crest varying from 17 to 36 feet above the low water-line, and width at top and bottom respectively from 3 to 4 and 5 to 8 feet.

20. Upon what foundations this wall rests, is matter of the purest speculation at this day. It is not known in fact to have any foundations* whatsoever, other than such as it has formed for itself by settlements, either gradual, owing to the action of gravity upon the loose soil beneath it, reduced as this is, during floods to a semi-fluid state, or again bodily, in the form of breaches after the subsidence of the waters.

21. I have heard a report to the effect that certain circular buttresses placed at various distances apart in the length of wall between last year's breach and the salt golah bastion, *(vide* Pl. XXII.) are founded on wells† of masonry; but of this there is no proof that I can find. This portion is the one to which the more recent date of construction is assigned.

22. Pl. XXII. on the distorted scale of vertical measurements, 25 times larger than the horizontal, will, I think, be found to convey all further information regarding the revetments that is necessary, the object of the work, to preserve the light soil to its rear from attritive action of the flood is to a certain extent gained, and in this respect its use is undoubted. Did it contain in itself the elements of stability it would be highly valuable as a work protective from the full force of the Katjooree's flood, which bears upon the south side of the city; but the absence of any, or at any rate of a fitting foundation to withstand itself the flood's erosive action, renders its usefulness a questionable matter.

23. It is not during the height, but after the fall, of a flood, that breaches occur in the revetment wall. This is readily explained. The light soil in rear of, and under, the ill-founded wall, and the sand

* During the season of 1854-55, I underpinned several running feet of the revetment wall found baseless, two feet above low-water level.—J. H.

† Had these buttresses well-foundations, I do not think I should have failed of finding some trace of them, when one fell in last year at Husecree Ghaut. This one certainly was not well-founded.—J. H.

in front, are, on the syphon principle, reduced to a state of semi-fluidity, by the pressure of the high flood water. The sand (in front) at the toe of the wall is carried away by the erosive action of the flood, and fall in the river taking place more rapidly than that of the moisture in the mass to rear, a pressure arises, thence causing the light soil from below the wall to be forced outward, and down falls the heavy mass of masonry. This state of things can easily be remedied, as will be hereafter shown.

24. Of the embankments running between the ends of these revetments, I need say nothing, save that they are calculated to the attainment of the object of their construction.

25. I will now bring to a conclusion my brief remarks upon the city protective works, and proceed to measure the form and strength of present apparent enemy, the Mahanuddy flood. Inimically, as it appears, disposed before acquaintance, I entertain the fullest possible hope, that this sought and made, it may be converted into a friend, who, whilst performing vigorously the mission of its master Nature, without deviation to the right hand or the left, will assist us to ends, which, without its assistance rendered, we cannot hope to attain. I subjoin here

A GENERAL DESCRIPTION OF THE MAHANUDDY RIVER ABOVE CUTTACK.

26. My knowledge of the upper portions of the Mahanuddy, beyond the immediate field of my labours, in its bed between Bydessur and Cuttack, is almost solely confined to the facts of its taking rise near Bustar, in the Nagpore Territory, and after passing the towns of Sumbhulpoor and Sonepoor, and receiving, near the latter-mentioned place, the waters of the Tel Nuddy, of its entering the plains of Orissa Proper, at Naraj, as previously described.

27. For many miles above, and for 9 below, the village of Tickreeparah, shown in the Orissa District Map, the river's bed is rocky and irregular, and channel narrow, floods rising (I am informed by Mr. Samuells, the Commissioner and Superintendent, Tributary Mehals) to the extraordinary height of 60 feet, at least above cold weather level. At the distance below Tickreeparah named, the channel is found to open out to an average width of nearly 2 miles, a condition which it retains over a course of 46 to 12 beyond Bydessur, the place which I have selected as a farthest necessary limit for the commencement of my measurements of the flood, and whence the exact course of the channel

may be seen from Pl. I. to be narrowed through the passage between the Rootrapoor and Domeparah Hills, again expanded even to a greater extent than before, and lastly, contracted in width to less than half a mile, between the Hills of Sydessur and Dawakote, ere the debouchure upon the plains takes place, to which I have above alluded.

28. Measured along the line of mid channel, the distance from Bydessur to the mouth of the gorge at Naraj is 27¾ miles, thence to my quarters (3rd Pl. I.) on the Mahanuddy side of Cuttack and to the Lalbagh on that of the Katjooree (d. Pl. I.) 9 and 6 miles respectively. From the point on the Mahanuddy last-mentioned to the sea by the main stream is 58½, and by the more winding one of the Pyka branch, 1½ miles additional.

29. On reference to Table I. will be found (in the tabulated form so far superior to any other) all information as to the heights of rise, &c. &c. of the Mahanuddy flood of A. D. 1855, between Bydessur and Cuttack, the various widths of water-way at points where my transverse sections of the river have been taken, the sectional area of the flood, &c. &c. Tables II. and III. show the calculated discharges, various rates of inclination of the flood, &c. &c. and Pl. AI. showing its longitudinal section, gives that also of the lowest line of bed of the 90 miles of river immediately above Cuttack, a sufficient length thereof to illustrate the peculiarity (if such it can be termed in India, where it is the rule rather than the exception) of the channel. This may be described as a series of basins of various lengths, depths and breadths depending upon the power of the flood to tear up the bed, the strength or position therein of the numerous rocks with which it is interspersed or the banks rounded, to resist the action, vertical and lateral, and define the limits of the channel near the point where my section No. 9 was taken between the Sydessur and Dewakote Hills as proved by an 80 feet sounding. There is a portion of the Mahanuddy bed positively 16½ feet below the mean level of the sea.

30. From 12 miles below Bydessur to Naraj (*vide* Pl. I.) the lateral limit, though not continuously, is rigidly and clearly defined by hills or rocks. The bar to any general change in the river's course between the points named is most complete, other facts connected with the portion of the river named, important though they be to the general are not so to the particular, subject of this inquiry, I will pass them over, and notice the conditions of the river below Naraj.

31. At the head then of the Delta, on the consideration of which I now enter, is found a sandy tract of nearly 3 miles in width, whence the Katjooree takes its departure as mentioned above. The right bank of this broad channel is comparatively low and unembanked, of a light soil, offering little or no resistance to the action of the flood, whilst the left bank is generally of higher level, embanked when not so, in many places; and as in the upper portions of the river, defining permanently, by its rocky points, the limits to the lateral action of the flood. An exception in respect to the soil characterising the right bank may be made for a short length and breadth at Chargurreah village shown in Pl. II. the soil of which, a very stiff clay, places some restriction upon the encroachments of the river during floods, limited, unlasting, and purely local though it be. A low line of hill at some little distance from the right bank I must mention also, which will hereafter set a limit to the lateral expansion though now it is inoperative.

32. This sandy tract, of which I have spoken, is on the principles enounced by Captain Dickens in his Memorandum upon the Damoodah River "owing to the heavy deposits of silt brought down from the higher portions of the main river, and it has the considerable slope which such tracts are found to take at the heads of large rivers."

33. That the constant accession is not chimerical may be seen from Pl. II., showing the comparative states of the Delta head in 1840 and 1855 A. D., as ascertained from actual Survey. That the considerable slope exists may be clearly seen from Table II. appended to this Report showing the various inclinations of the flood line between points noted and (neglecting the falls between the hills due to afflux) the particular flood gradient between Naraj and my quarters on the Mahanuddy side, and again the place first named, and the Lalbagh, on the Katjooree, to be greater per mile than in any portion mentioned there. The 130 last miles of the river's course from Tickreeparah to the sea, in its passage over this tract of sand then where the river is most powerful for evil or for good, must the Mahanuddy be controlled. On the state of this tract depends chiefly the distribution of the waters. The Survey of 1855 was made by Overseer J. McMillan than whose map, from which Pl. II. has been reduced, I have rarely seen a more valuable production of its kind.

34. I would here notice again the fact of at least a third of a mile in breadth at the Katjooree's right bank having been carried away

during the past fifteen years between Naraj and Chargurreah (Pl. II.) and that also of considerable lateral expansion being in course of operation on the principles explained by Captain Dickens.

35. Before proceeding further, I think it desirable to consider in this place certain principles upon which the action of rivers appears to me to depend. Many of these have received such ample enunciation and explanation by Captain Dickens in his Memorandum upon the Damoodah River, which has lately been before Government, with other documents bearing on the same subject, that the mass of labour is saved me in generally soliciting reference to the printed pamphlet. This I do, at the same time, however imperfectly I may perform it, I will not avoid the task of reconciling to common sense the main principle adverted to in the pamphlet regarding which great misapprehension exists, and from which false deductions have been, I think, and may be drawn freely.

36. I allude to the so-termed phenomenon remarked by Gennété, an Italian Engineer, "that a large water-course could receive all the water brought into it by an affluent of considerable volume without any sensible augmentation of the height of the water line or increase in the width of the bed." Whence he deduces that it would be useless to endeavour to lower the level of waters in Deltas by making fresh channels; other Engineers, adopting the general proposition, give out "that neither in width nor depth need a stream be altered by receiving one or more affluents;" and so on through all the changes that can be run upon variety of cause and constancy of the effect thereof.

37. To the unprofessional reader, the field of doubt thus opened out, must certainly appear too extended, to make it worth while, applying the test of his own common sense to any enounced principles whatsoever of the action of large rivers. I will therefore endeavour to show that the phenomenon is a construction of Signor Gennété's, really unattended by any thing bordering on the marvellous—the only result that could be expected by an observer of Nature's principles of action. Italicising the word sensible and using it in its most limited signification, I can assent most fully to the proposition, for a general increase in the flood line of both main stream and affluent both above and below the point of junction, due to the latter would not be sensible (in the limited sense I use the word) and again the width of bed dependant upon so many other considerations besides volume, need not be sensibly affected by even a considerable increase thereto.

38. As italicised below, I can assent most readily to Gennété's deduction "that it would be useless to attempt to lower the level of waters in a Delta by making fresh channels;" not as a deduction from his proposition though, which is untrue, of waters in a Delta the beds of which must widen or the banks be inundated, which is to all intents and purposes a widening of the bed—though temporary as an effect, equally so the operation of the cause—increased volume.

39. Simple as is the subject of a river's rise and fall, misapprehension or but partial comprehension of the laws which regulate these, there must be, or phenomena such as I have mentioned, would escape construction. I will consider the simple questions—

What is a river? How do rivers flow? What regulates their surface levels?

40. A river is a series of basins of gradually receding levels, from its source to the sea, terminating in the last, equally a basin, though comparatively speaking, of unlimited extent. Such basins filled partially, wholly, or running over, as the case may be, with particles of fluid yielding to the slightest force or pressure, each independent of its fellow, all on the same errand, finding their lowest possible position in the series of receptacles in subjection to the law of gravity, falling where they can find space to fall, rising never, inseparable (or rather having no tendency to separate, but on the contrary) naturally, from the moving column, the one great whole of which each forms a part, the while an independent material atom in itself, indestructible, occupying space, impelled at various velocities according to the changes of its position in the mass; at one time travelling onward at topmost speed in the crest of the line of current, at another retrograding calmly in a stream's back-water; now low, now high, relatively in the section of the column, still never rising in the plane of motion; now moving at a high velocity, exerting the pressure of its atomic momentum in accelerating the movement of tardier journeying particles, and itself retarded by resistance offered; now becoming the accelerated and retarding particle in turn. Throughout, the movement of each particle is onward in the main, the mass of which it is an atom, is rolling forward down the general incline, with a velocity proportional to its own weight and the gradient of the plane, formed of its own atoms, down which it glides.

41. As with the minutest possible sub-division of a river, the particle, so with all greater, even to the grand division of its upper and

lower portions during flood. Accelerative force is even exerted by the higher in position, retardatory by the relatively lower, and ever is an onward movement of the general mass under the subjection to the laws of gravity to which its every atom stands.

42. In respect only of the varied ratio of the accelerative and retardatory action of its parts, does the moving column of a river's waters differ from the body of a serpent, throughout the entire length of whose frame is felt each movement of its smallest part. The analogy is complete in the case of a regular channel, of which supply and discharge are precisely equal. Here we have the accelerating and retarding forces in equilibrium, and a constant level of the general water line. When this is not the case, is produced in a river the rise or fall, the alteration of the general water line, in a manner which I will endeavour to explain.

43. Correctly speaking, the accelerating and retarding forces in the particles or portions of a river are opposite and equal, but by the former I intend to signify the momentum of the upper particle, sub-division or division, of a stream, and by the latter that of the lower. On the ratio of these moments to each other depends the rise or fall of the general flood line. On their ratio, in lesser divisions of the stream, depends local level; on the same amongst particles, depends their position in the moving mass.

44. Were a column of water moving in a regular channel, in the state I have described above as analogous to the body of a serpent, to receive at, and regularly thereafter, from any instant of time from a higher level than its own, any fixed extra supply, this would, (practically speaking,) glide down the inclined plane of the surface of original column, eventually increasing the depth thereof throughout by a constant quantity, causing matters to return to the original conditions, saving of general level, on which rise will have been effected. The identical particles which started from above the surface of the plane of original mass will not have retained their first position as I have shown above, but the addition to the longitudinal section of the stream will have taken place precisely as if they had. It will have gone through the stages of a triangle with little or none to one having a base, the length of the stream's whole course, and eventually into a parallelogram, upon the restoration of the equilibrium of the forces of acceleration and retardation (in the sense I use them). The point I am anxious to draw

particular attention to is the distribution of this effect of any difference between the forces named over the whole length of channel—the general nature of the action of even the veriest particle upon the mass.

45. Here then we have, in a regular channel, a fixed accession of supply of particles, at the head productive of a at first local, and eventually general, rise. In the same manner it may be shown that a fixed diminution of supply at the head will be productive of local and general fall, also conversely.

That extra draught or obstruction afforded at the tail of a regular channel will be productive of fall and rise respectively, local at points, in general throughout the course of the channel.

What is true of the effects of accession or diminution of supply at head and tail is equally so of these taking place in any intermediate portion of the course of the regular channel. What is true of the latter is true of one however irregular. Nature's laws apply alike to all: they know no irregularity: their action cannot reduce to insignificance, general are they and general is their effect.

46. The common-sense view then of the matter is undoubtedly in favour of the general effect of the unity of the mass of particles forming the fluid body of a river. For corroboration to some extent of this view, I would solicit attention to the table showing hourly rise and fall of the Katjooree, (Pl. XXIV). For the peculiarity of the features marking the subsidence of the great flood, I can in no way account so satisfactorily (in the total absence of any rain fall at or near Cuttack) as by assigning to the earliest part of it (where any general effect would have been most operative) the periodical draught and obstruction offered alternately by the ebb and flood of the sea 58½ miles distant, great though the distance be. The extent again to which the great flood penned back from Ruttaghur (*vide* Pl. I. A.,) evidences this generally distributive effect of local obstruction (in this case or draught in others) which, convinced of most thoroughly myself, I am anxious to see established.

47. I will now take up the particular case upon which Gennété has constructed his phenomenon. "A river, (somewhere on its upper portion, not its Delta), is joined by an affluent, this unattended by any sensible augmentation of the height of the water line, and not necessarily by increased width of channel." The extreme dimension I could possibly assign to such affluent (and this is also the case with the veloci-

ty) to that of perfect equality with the main stream, for otherwise the affluent becomes the main, for purposes of argument, the main the affluent. I will therefore treat them both as similar in all respects. We have now two (instead of one) equal moments of accelerative force, the relation of the result, out of which to the moment of the retardatory force below the point of confluence regulates the general level of both rivers, above, at, and below, the point of affluence, generally throughout their courses. To the mind comprehending thoroughly the general nature of effect produced by these two bodies of water one on the other, will be sensible (in the widest signification of the term) to the portion of the height due to a second half of the joint volume. Where this apprehension is imperfect, no evidence, save optical, can bring conviction with it. To obtain this, the affluent must be entirely cut off from the main stream and the difference of effect witnessed. So much for augmentation of the height of the water-line due to affluence of a second stream, which is, I say, not sensible to the eye of the casual observer, but sensible, in the highest possible degree, to the pains-taking observer and student of Nature's laws.

48. But how, it will be said, is no sensible increase to the width of channel necessarily involved? I will endeavour to explain this also. The regimen acquired below the point of confluence (I must suppose this to have been effected, or widening is no impossibility, far from it) has been dependent on volume to be discharged, on general declivity of country, on the nature of the soil, &c. &c. not in any way upon the number of the channels whence the volume is supplied. The depth, width, form, and velocity of the confluent stream is thus determinate on the above and other various considerations. Now the streams above the point alluded to, passing through similar soil, over country of the same general incline, have slopes of bed generally differing insensibly from that below, influencing and influenced by each other; their tendency to similarity is clear, any difference would be distributed generally over a considerable length, the maximum depth would not (certainly need not) vary sensibly, it would not be optically observable.

49. In respect of width again, a portion of their width (where this from circumstances of soil is capable of alteration) is due to a decrease in velocity caused by the retardatory action of each stream on the other, on the principles I have previously expounded. As this is exerted with considerable force at point of affluence and distributed

generally by each up the other stream, causing a decrease of velocity, considerable in their lower portions, and less and less higher up the streams, we may safely argue considerable width, due to affluence, at the point of it, in which a gradual diminution takes place higher and higher up. This augmentation, below the point of affluence, is not sensible only, inasmuch as it has produced a similarity of width above and below point of affluence, distracting attention from its having formed a feature in the change the original affluence brought about.

50. The simple fact reconcileable to theory, to common sense to Nature's laws is this, that ere a stream can re-acquire its regimen, after being joined by an hitherto independent stream, the following changes will have taken place, under any circumstances of soil and declivity of country :—

1*st.*—Increase in width or depth (or both) above and below point of affluence.

2*nd.*—Increase of velocity in main stream below point of affluence.

3*rd.*—Decrease in velocity of both main affluent above the point named.

4*th.*—General rise of water-line.

51. Conversely from the above we may infer that to relieve a river of a portion of its waters by formation of a new channel would, whilst lowering the general water-line, increase the velocity above, and decrease that below, its point of departure. Such would undoubtedly be the case, and permanent would be this effect in a river running over a firm bed throughout its course to the sea, not so however in channels in a Delta of light alluvial formation, having a tendency to rise of bed, directly proportional to the matter brought down from the higher portions of the river's course, inversely to the power obtaining in the lower to carry this off. It is on these grounds of argument, I would not attempt lowering the water-line in a Delta by cutting new channels.

1*st.*—By doing this, I should be increasing velocity above, and consequently the amount of matter brought into the Delta channels from the higher portions of the river, would be subjected to an accession, decreasing the velocity below and crippling its discharging power, thereby producing instant fall of water-line and gradual rise of bed, the former effect, an advantage as uncertain and temporary, as the latter an evil undoubted and permanent.

52. I shall have occasion to pursue this subject further hereafter, when reporting on the district; for purposes of present inquiry, however it will suffice to make one single deduction from the above, viz. *that concentration of the waters of a Delta, of light alluvial formation, rather than their distribution into a number of channels, conduces to the efficiency of the discharging medium, and that alteration of general water-line caused by such concentration is not lasting in effect.*

53. The next effect of the action of rivers which I have to notice, not as a phenomenon, but an easily explained fact, and one most important of consideration in Engineering matters, is that the upper surface of the transverse section of a flood is not an horizontal line but (a curve, or for purposes of argument say) a triangle, the apex of which is variously situated in such transverse sections according to the position in them of the point of maximum surface velocity. These points of maximum velocity and level form a connected line, following generally the path of greatest depth, called by German Engineers the "thalwag"* of a river. In a straight line, where this path lies in mid-channel, the upper surface of the transverse section of the flood will consist of two equal inclines from centre of stream to bank on either side. This is owing to excessive velocity in the topmost particles, and to the centrifugal force in a vertical plane which they acquire from their position. Now, if a river's course be winding, the path of greatest depth will cross and re-cross the stream, and so also the line of maximum velocity and level, and the position of the apex of transverse section of the flood will be such that its upper surface will consist of two inclines of different lengths of base, between the line of maximum local levels and the banks.

In addition to the motions produced in a straight run, in the topmost particles of flood water, we have, if the general direction of the stream be tortuous, a centrifugal force acting horizontally upon them, tending to carry the maximum line of level beyond the path of greatest depth even towards the convex bank. The disproportion between the bases of the inclines in upper surface of flood section is thus oftentimes so large, that they practically form one great incline from convex to concave bank.

54. I have unfortunately but two indisputably correct high flood-levels at precisely opposite points in the general direction of the Mahanuddy river. These are at Bydessur and a village opposite, and their

* *Thal*, "a valley," *Wag* "a road."

difference 1 foot, the width from bank to bank being $1\frac{3}{4}$ miles. Bydessur, at the convexity of a long gradual course, has, as might be supposed, the higher flood-levels. Between the flood-levels taken at my quarters and just below the head of the Beropa river, again, there is a difference of upwards of 3 feet, of which 2 at least are due to the disparity of level obtaining at opposite banks of the river, the distance between which in this case is $1\frac{1}{2}$ miles. The principle may from Pl. I. be seen to operate to a very great extent.

55. It may be laid down then as a principle, that local level of a flood at any point in a river's bank, is influenced sensibly by the direction of the path the current takes.

56. On the principles mentioned above, inasmuch as they appear either insufficiently explained or unnoticed in the Damoodah pamphlet, and such as are therein brought to notice, I will endeavour to trace the action of the Mahanuddy's flood of A. D. 1855, as Colonel Goodwyn truely remarks in the concluding paragraph of the pamphlet. "A question of this kind should be regarded as a physical rather than a mathematical one. Tables and formulæ, however correctly and elaborately prepared, though very useful in support of generally received hydraulic doctrines, are only really and practically valuable when in harmony with the laws which nature has written on the beds and banks of great water-courses." Let me consider then to what results mathematical calculations will lead, and in what points these harmonise with each other and with nature's laws.

57. Adopting the hydraulic formula of Etelwyn, I have drawn up Tables I. II. and III. attached to this Report, showing results conflicting to a degree considered independently, but they may be still used to guide us to the truth exposing to us, as they so plainly do, taken in connection the line between the physical and the mathematical, which must be drawn to reach the truth approximately in respect of the volume of the flood.

58. Bearing in mind the conformation of the Mahanuddy between Bydessur and Cuttack previously described, the diversity of circumstances attending its flow between points named, and recognising, to any extent the principal of unity of mass, &c. &c. which I have endeavoured to establish, it will be allowed at once that the passage of flood through the various coupled sections, could not possibly have taken place at the theoretic velocities due (in a regular channel) to their sections and the

fall of flood, or rather bed, between them. That the fall of bed is not fairly represented by the fall of flood in the irregular, as it would be in the regular channel, we are shown at once we must look for other measure of the former. To this conclusion our mathematical calculations have assisted, also do they show the path which we can take, with least degree of error, as a probable result, viz. to accept the three first sections as the measure of the river's capacity of channel.

59. Taking then the average of Sections A B. C. D. and E. F., and assigning to the slope of bed the general fall per mile between Bydessur and Naraj, we obtain subjoined data on which to calculate discharge :—

Sectional area	217361.
Mean depth	23·40
Fall per mile.....	1·64

Whence velocity by Etelwyn's formula is found to be 8·01 per mile, giving the discharge

1,741,062 cubic feet per second.

60. The island in Section A. B., confining its water-way in a sensible degree, a better measure would be perhaps obtained as far as sectional area is concerned, from combination of Sections C. D. and E. F. whose average is 2,27,190 square feet, which at a velocity of 8 feet per second, would give discharge

1,816,720 cubic feet per second.

61. Again the average of the theoretic discharges, vide Table III. is

1,797,746 cubic feet per second,

whence it appears that the probable discharge of the Mahanuddy during the heavy flood of 1855, was

1,800,000 or thereabouts,

as far as can be ascertained from Sections taken in the upper portion of the river.

62. Over-leaf will be found a Table showing the general distribution of the waters near Cuttack, into the river's various branches. Here again the search after the actual is assisted much by a consideration of the theoretic discharge obtained from mathematical calculation. We have little of theoretical result to notice as at variance with observed facts, simply the undue velocity assigned by theory to the Katjooree after throwing off the Kokai. In this case a heading up at the Salt Golahs proved to have taken place, as also a scouring and deepening

of the bed, where Section C. K. was taken, in consequence thereof have affected unduly the calculations of "velocity" by exaggerating the "fall" and "mean depth" of the branch. On the adjustment of this manifest error, it will be found that dividing and sub-dividing again the waters of the Mahanuddy into the branches near Cuttack, the theoretical calculations are reconcileable to each other, and to facts which assign to the Mahanuddy and Katjooree velocities of 7 feet per second during high flood.

Table of Discharges of the Mahanuddy River and its Branches, drawn up with reference to paragraphs 60 to of this Report.

RIVER.	Letter.	Plate.	Sectional Area.	Fall of Flood per mile.	Calculated Velocity by Etelwyn's Formula.	Calculated Discharge.	Joint Discharge.	Remarks.
Mahanuddy ...	Average of A B C D & E F		2,17,361	1·64	8·01	17,41,062	17,41,062	Under the mark, possibly for reasons given in para. 60.
Ditto	Average of C D & E F		2,27,190	Velocity assumed *vide* para. 60.	8·00	18,16,720	18,16,720	Agreeing well with combined discharges of Mahanuddy and Katjooree as an average valuable corroboration.
Ditto	Average of 9 Sections taken from Table III.				... ..	... ...	17,97,746	
Ditto	8. *h.*	XVII.	1,45,687	1·84	7.15	10,41,662	18,20,188	Velocities as nearly as possible what they actually are.
Katjooree ...	*s. c. d.*	XVI.	1,06,356	1·76	7·32	7,78,526		
Ditto	*l. k.*	XVIII.	57,934	2·20	*9·04	5,23,723	7,88,768	Calculated velocity much above the actual in the case of the Katjooree, probably that of the Kokai under the mark, but not much, leaving 9,06,860 to be carried off by the Mahanuddy and Pyka after.
Kokai	*e. f.*	XIX.	39,500	1.70	6·71	2,65,045		
Beropa.....	*l. m.*	XX.	22,467	Not known	Assumed 6·00	1,34,802	1,34,802	

63. I would here notice casually a fact, which, self-evident and simple, I have not yet had the opportunity of investigating, and cannot therefore treat upon, viz. that, traversing long courses unconfined, an "accelerated velocity" is due to large rivers, over and above that which theory assigns them; and again, that when their free discharge is interfered with, the theoretic discharge should be subjected to a deduction for retardation of velocity involved.

64. Applying this principle to the question of the Mahanuddy's discharge, conclusion may be drawn that near Bydessur and from Naraj, past Cuttack, actual velocities were respectively greater and less somewhat than those assigned to them in the various tables to which I have referred above.

65. Under all circumstances then, I am inclined to regard, as I have said before,

1,800,000 cubic feet per second

as the discharge, in round numbers, of the Mahanuddy during the extraordinary flood of A. D. 1855, and with reference to Sections A B and G H

1,850,000 cubic feet per second

to have been about as nearly as possible that of the flood of A. D. 1834, the greatest which has occurred within the memory of man.

66. The preceding paragraphs will have conveyed sufficient idea of the magnitude of a Mahanuddy flood, rolling, as it does, its 50,000 tons of water per second of time, past the town of Cuttack. I will therefore proceed to give a sketch of the local effect of the flood of 1855 upon the town and its protective works.

67. Passing unnoticed for the present the earlier stages of the inundation, which reached its height on the 29th July last year, I would remark on the actual status of the town during the critical period of maximum flood-level obtaining in the two huge columns which bore down upon the place.

68. Differing but little in velocity and having no very great disparity of volume, these vast bodies of water approached to the assault under circumstances of a very different nature. The Mahanuddy running the more lengthy course of 9 miles from Naraj, passed my quarters ($\frac{8}{4}$ in Pl. I.) at a level of 121·13 on the Division datum: its velocity and direction of current perfectly harmless in their operation and affecting merely by the level of its waters (low though they were compared with

those of the Kajooree) the conditions of the town. Bursting, however, the inefficient and but partially* repaired embankment between Cuttack and Jobra, the waters distributed themselves over the plain to the eastward of the town, forcing their way inside the embanked road which protects the town to the rear, through the Budje-kew at Sluice-gate† ill-suited in condition to the emergency.

69. On the other hand how different the action of the Kajtooree river! Its course, direct as the crow can fly from Naraj to the revetment, and that course 6 miles only, continued into the Lalbagh; the flood reached 127·13 on the Cuttack Division datum, 6 feet higher than the level of the Mahanuddy on the north side of the town. Its level, direction, and velocity of its current each produced a maximum amount of evil. Tearing up the sandy bed at the toe of the revetment wall under influence of direction and velocity of current, topping the wall by virtue of its high level, away tore the ruthless stream, bursting below Cuttack the Kannugur bund, and throwing off a portion of its waters to deploy and mingle with those of the Mahanuddy in the rear attack upon the town.

70. Encircled by the waters of the two rivers in the way I have shown above, the one superior to the other by 6 feet in level, bearing down directly upon the revetment wall with a velocity of at least 7 feet per second, topping it in several levels with its crest in many places (see Plate XXIII. Table IV.), the situation of Cuttack was critical indeed on the 29th July, 1855. It is without my province to chronicle the state of public feeling prevailing at the time, and did I possess the necessary powers of description, my heart would sicken in the attempt at the recollection of the apathy‡ displayed by the inhabitants, the awful

* A strong line of embankment has been constructed between points named this season.

† At the request of Mr. R. P. Harrison, late Magistrate of Cuttack, I have since supplied this sluice with massive self-acting gates, calculated to remain efficient for many years to come.

‡ Not a single native, saving the Police, whose conduct owing to the vigorous administration of Mr. R. P. Harrison, the Magistrate, was most praise-worthy, could be found to render this department the very smallest measure of assistance, and though it was proclaimed by beat of "tom tom" that in the event of the river rising at the rate it was then doing, an hour longer, inundation could not be staved off, I found the apathetic Ooriyas sleeping at their door-ways on the morning of the 29th July, when returning to my quarters to take a few hours' rest after a wakeful night spent in their service.

On the morning of this day a lull of two hours took place, as if dispensed by Providence to urge further exertion on our parts. Nobly was advantage taken of this by Assistant Overseer McMillan, who, assisted by Mr. R. P. Harrison with 500 sand-bags belonging to the Salt Department, continued the construction of the parapets and kept down the final struggle of the flood. A hard race with time was this which Assistant

danger pending over 35,000 of my fellow-creatures, which no exertions of my department could avert, if a few inches further rise should take place. Suffice it to say that, by constructing parapets of sand-bags, the town was saved until the crisis was overpast.

71. From Pls. XXI. and XXII. and Table IV. will be obtained a far better idea of the danger to which Cuttack stood exposed than any I can otherwise convey. The former show clearly the maximum height attained by the flood and the probable effects of inundation; and from the latter will be seen that a very trifling rise, in addition to that reached at the crisis, would have so divided the attention of this department that had materials been at hand (which was not the case, every sand-bag procurable having been expended) the utmost efforts must have succumbed to an hourly rise of 2 inches of flood-level.

72. The above sketch of the prominent features of a particular and extraordinary flood will suffice to convey a true sense of past danger, as also of the measure of that attending recurrence of a similar flood—but this is not all that need be known of the flood conditions of the Mahanuddy and Katjooree rivers, I must yet reply briefly to the questions.

1.—Was this flood a maximum in respect of volume?

2.—Are the conditions of the rivers named above, capable of alteration in such wise as to produce further unfavorable effect?

3.—Could local circumstances of any kind bear unfavourably upon general conditions.

73. To the first question I would answer, "No." Though of less local level at Lalbagh, the flood of A. D. 1834 was larger in volume by some 50,000 cubic feet per second than that of A. D. 1855. How much greater a flood may have occurred or occurs, is without the field of argument, as is such greater flood within the range of probability.

74. With respect to variation of conditions, I would remark, in reply to question 2, that the Katjooree has, I think, done its worst* in the matter of the direction of the current; which cannot be more unfavorable than it is at present. In volume it may be materially af-

Overseer McMillan ran, but the victory was his, and the Government in recognition of his exertions promoted him to full Overseer—an act as gracious (being without precedent) as the reward was merited.

* I speak solely with reference to its local effect upon the town of Cuttack, the general tendency of the river being towards enlargement southwards; the desolation of the Pooree district must eventually result, unless precautionary measures are taken.

fected for the worse, as also in velocity and mean depth (its consequence) from variation of local levels at Cuttack (depending on the direction of the current, as I have shown it to do in paragraph 69), I anticipate no ill results. It may be presumed also, that the gradual deterioration of the Mahanuddy's channel, which is progressing hand in hand with the enlargement of the Katjooree, will be unproductive of direct unfavorable influence, though indirectly of course it affords assistance to the Katjooree's unfavorable action.

75. Lastly, in reply to question 3, I would observe that local rain or wind (which were not operative during the flood of 1855, whatever they may have been in 1834) might sensibly affect local level at the critical moment of maximum rise of river; and that again, high spring tides (to say nothing of a heavy gale on the Coast), would, in my opinion, have sensible effect upon the local level if their maximum of obstruction were offered at the precise period of the crisis here. The flood of A. D. 1834, to which I have above alluded, is reported to have taken place in between the 13th and 17th of the month of October of that year, whence I find the moon to have passed from its 10th to 14th day, and neap tides to have prevailed throughout the flood.

76. Having considered the above questions, I will endeavour to state the probable

MEASURE OF DANGER TO THE TOWN,—ITS CAUSE AND REMEDY.

Treating of the two latter simultaneously with the former, as will be most convenient for general purposes of elucidation of the subject, and looking to concluding my Report with a more particular mention of the remedial measures I consider necessary.

77. A combination of all the unfavorable conditions and circumstances I have shown to be possible above, i. e. a flood, such as, or even greater than, that which occurred in 1834, reaching its highest local level at Cuttack simultaneously with high spring-tides and South-East wind on the Coast. This wind (or worse a South wind) blowing heavily at Cuttack and rain-fall from the hills close by, discharging itself the while, would, undoubtedly, cause the inundation and destruction of the town. Of this I have not the slightest shadow of a doubt. The Katjooree's waters rising to the level due to such circumstances, would effect this did it merely top the revetment wall and fill the basin which the town forms, but the surface of the flood would not be the only portion thereof brought into play. Embankments would be burst,

the upper portions of the revetment wall, barred by the rush of water down their sloped backing would be broken down, and the Katjooree and Mahanuddy would unite their waters with a velocity due to the fall of 6 feet and more in two miles between their surfaces south and north of the town. The effects of local level due to circumstances supposed, could not be combatted successfully, I feel convinced. The concurrence of such circumstances (far from a remote contingency) we should be prepared to meet, where the lives of 35,000 human beings may at any moment be sacrificed by want of action in the adoption of precautionary measures. The cause of the high local level attained in these days by the floods is undoubtedly the diminution of the length of the current's path from Naraj to Cuttack which has taken place, assisted by the direction it has acquired. The remedy is clearly to be found in either heightening the protective works to meet altered conditions of flood, or, on the other hand, to bring these back, by artificial means, to their pristine state. The sequel will show that the latter course is beyond a doubt the one to be pursued.

78. Direction of the flood's current I have shown in paragraphs 53 and 54 to be productive of extra local level, a point which has just received consideration, but I have yet to point to it (with reference to paragraphs quoted) as a cause of the high velocity obtaining at the point where the current strikes the revetment wall, and of the deepening action which produces breaches in that work (vide paragraph 23). We have not here the choice of remedies, the alteration of this direction is the only one.

79. Lastly, we have a tendency to deepen its bed in the Katjooree river due to the velocity produced by yearly increasing volume, for which but one remedy can be applied, an alteration of the distribution of the Mahanuddy's waters at Naraj involving a change in the direction of those of the Katjooree's branch.

80. A concurrence of various unfavorable circumstances, it thus appears, would be productive of the certain destruction of the town, a consequence simply of the level which an extraordinary flood would under them attain. It remains for me to remark upon the probable effects of the velocity and direction of current of the Katjooree now obtaining. Here no extreme circumstances need be called up to show the danger the town is in from these. An ordinary flood, such as Cuttack is exposed to yearly, twice or thrice, would inundate the town

in the event of breach occurring during flood. As explained in paragraph 23, such occurrence is not usual, but that it may take place, will be readily allowed, I think.

81. The city of Cuttack then containing 35,000* human beings, is liable to inundation from floods such as ordinarily occur twice or thrice a year, to destruction from such as occurred in A. D. 1855, after a lapse of 21 years (under circumstances favorable to the salvation of the town.) These are the dangers to which Cuttack stands subjected. Their measure may be variously inferred, but they will be allowed, on all hands, to be great, I feel assured.

82. The cause of existing danger, as I have said above, is to be found in the town's conditions with respect to the Katjooree river, the direct course, velocity, volume, and direction of current of which each exerts almost its maximum of evil.

83. A common remedy there is, and only one,—an alteration of the distribution of the Mahanuddy's waters in such manner as to increase the length of path of current of the Katjooree between Naraj and Cuttack, diverting it the while from the revetment, and to decrease its volume.

84. At Naraj is the point to effect this, for reasons given in paragraph 33, and the essentials of the remedy and point of appliance being thus determinate, I will proceed to point out what I deem the

NECESSARY REMEDIAL MEASURES.

85. The existing conditions of the Mahanuddy and Katjoorce have been produced, as I have endeavoured to show in the preceding pages, by the gradual operation of Nature's laws during the lapse of centuries. By its assistance alone can change in these conditions be brought about. Such change then must be gradual, in conformity with Nature's movements. Little by little must the branch be led to abandon lofty schemes of conquest to the southward, and the main stream be reconciled to bearing the burden it has once thrown off. Feeling assured that this must be, I had rather incur the charge of recommending measures uncalculated to ensure prompt and efficient remedy, than connect myself with any recommendation of an extensive work, such as, if it had been existent for a score of years or more, would now control effectually the distribution of the Mahanuddy's waters.

On the authority of Mr. Shore, Collector of Cuttack, I state the Census of 1854 to show the number of inhabitants 34,770, of houses 6,954.

86. The construction of a "perfect weir" from Naraj to the head of the Peninsula, on which Cuttack is situated, is what I would recommend, could the execution of the work be extended over a long term of years, and if the permanent well-being of the city for centuries to come were paramount to all other considerations, as it is not; for outlay on posterity's account is not demanded to the extent involved. I advocate, in consequence, the construction of a work and the pursuance of a plan of minor operations, calculated to afford a considerable measure of immediate relief to the town, and such as, destructive of all evil tendencies now operative in the Mahanuddy and its branch, would interpose others, favorable to constantly progressive improvement in all points where deterioration is now in progress.

87. By throwing an "imperfect weir" in the direction shown in Pl. XXV. across the Katjooree's head, and operating judiciously upon its bed near Cuttack, the subjoined results may be reckoned upon as certainties :—

1*st.*—Improvement of the Mahanuddy's bed, due to constant mild scour, throughout the rainy season.

2*nd.*—Discharge, by the single stream, working during low floods, of a greater amount of sandy particles than could be effected by the two working together, and a consequent diminution of the tendency of the bed of the main stream to rise, owing to deposits taking place whilst the river runs at small velocities.

3*rd.*—Enlargement of the channel of the Mahanuddy in its passage over the Delta's head, enabling it to receive during high floods extra volume, for the discharge of which the scour of its bed will fit its lower portions.

4*th.*—Thereby producing draught in the direction of the main stream tending to carry the "path of current" in high floods considerably beyond Naraj, before its division into the two branches which it takes, causing a lengthening of the "path of current" in the Katjooree between Naraj and the town, and operating favorably upon the direction of the same.

5*th.*—Changes in length and direction of the "path of current," of which both effect reduction in local level at Cuttack, and the latter, a diminution of the main cause of danger to which the town now stands exposed; previously shown to be the velocity, volume, and direction of the Katjooree river.

6th.—Independent of the indirect reduction of volume and velocity due to the branch's (practical) departure from the main stream lower down than it does now, and, consequently, at lower level, a direct reduction due to the existence of the weir.

7th.—As a result of brush-wood operations, the entire silting up of the Katjooree's channel running under the toe of the revetment wall and the opening of a less objectionable one in the centre of the stream.

88. Of the practicability of effecting the results required of the minor operations, I can not only speak with confidence but without fear of contradiction. A reference to Pl. XXII. will show the practical effect of brush-wood operations carried out last year on a small scale. At an expenditure of Rupees* five hundred (Rupees 500-0-0) upwards of 5 million cubic feet of sand were lodged under the revetment wall, reducing the depth at one important point no less than 30 feet. Time is the only limit to what can be done by simple means such as those used. This, not money, is the important item of expenditure.

89. Of the results of construction of a weir such as I propose, I have spoken as certain, feeling them to be so; but this is necessarily matter of opinion. That they are certain, however, I have no hesitation of advancing as my own. It now remains for me to give approximate estimates of the cost of weir and minor brush-wood operations.

90. Assigning to the former the Section which, on a late tour of inspection, the Superintendent of Embankments recommended for adoption, or dimensions of

Breadth of Lip.....	20	feet.
Front Slope.....	5 to 1	„
Rear Slope	3 to 1	„

the average height being 13 feet, and the average length being 4,900 feet, the cubical contents of the work may be taken at 3,950,000 cubic feet, and the cost at Rupees 98,750, at a rate of Rupees 2-8 per 100 cubic feet, at which I have little doubt the work could be substantially executed.

91. I should have every confidence in reducing the dimensions named above and giving front and rear slopes of 2 to 1 and 1 to 1 respectively, on which data the cubical contents of the work become reduced to 25,160 cubic feet, the cost to Rupees 62,900.

* Whilst silting up one channel, I was forming another, the value of which has not been taken into account.

92. To either of the above sums might be added 6 or 7,000 Rupees as a maximum estimate of the cost of brush-wood operations in the Delta head generally, of which one-fourth would be expended in silting up the Katjooree's bed near Cuttack, the larger share in assisting or counteracting, as the case might be, the action of the weir.

93. Fifty per cent. on prime cost of the work should, I think, be allowed for sinkage of the material first laid down and for repairs, which, for a few years, might be necessitated, so that the estimates might be

Maximum	1,50,000
Minimum	1,00,000

or thereabouts.

94. Plates I. and XXV. accompanying this Report show dotted lines on the Mahanuddy's left bank. These indicate alterations therein, which, it is reasonable to suppose, would follow the removal of material for the construction of the weir from certain localities, whence I propose drawing supply with double object of improving the Mahanuddy's course and obtaining my material.

95. Lastly, I have to notice Table V. appended, the standard of the movements of the Mahanuddy and its branch, whence deterioration or improvement may be ascertained at any future period.

96. Let me here bring my subject to an end, with the expression of a hope that I may not have failed entirely of imparting some share to others of the interest I naturally feel in it. Under a sense of the high responsibility incurred, in a matter on which depends the safety of 35,000 of my fellow-creatures, I have endeavoured to place before Government, in its true form, the danger to which they stand exposed. The causes which have led to present state of things I have investigated honestly and thoroughly, and the remedy which appears to me to be demanded I have shown, a standard also have I furnished whereby to measure future danger. Here the grave responsibility with which I have been charged has its end.

JOHN C. HARRIS, *Lieut.*,
In Charge Survey, Cuttack Rivers.

APPENDIX.

TABLES

TO ACCOMPANY

LIEUTENANT HARRIS'S REPORT.

PART I.

TABLE I.

TABLE showing the Sectional Areas, Peripheries, and Hydraulic Mean Depths, &c. &c. of Transverse Sections of the Mahanuddy River and its Branches between Bydessur and Cuttack.

Number.	Letter.	Plate.	Distance from Bydessur. Miles.	Furlongs.	Feet.	Across what Rivers.	Between what Villages. Bank. Left.	Right.	Length of Water-way between Banks. Miles.	Furlongs.	Feet.	Levels reduced to Division Datum. Surface of Flood.	Lowest point in Bed.	Maximum Depths of Water. In high Floods.	In cold Season.	Difference rise of Flood.	A. Sectional Area of Flood Channel.	P. Periphery of Flood Channel.	A/P Hydraulic Mean Depth of Flood.	Remark.
												Feet.	Feet.	Feet.	Feet.	Feet.	Sq. Ft.	Ft.	Feet.	
1	A. B.	III.	...	...	...	Mahanuddy	Gopinathpore ...	Bydessur ...	1	4	418	183.33	140.80	42.53	13.15	29.38	197904	8059	24.56	Letters correspond to Plans and Sections.
2	C. D.	IV.	6	2	100	Ditto	Kamaraing Hill	Bherah ...	1	7	41	174.90	131.59	43.31	7.60	35.71	229246	9967	23.00	
3	E. F.	V.	10	...	400	Ditto	Anandpore ...	Chirchike ...	1	6	604	169.59	111.89	57.70	19.05	38.65	224934	9933	22.64	
4	G. H.	VI.	16	2	400	Ditto	Soobunapore ...	.....	.....	7	67	164.70	115.94	48.76	6.45	42.31	191220	5014	38.14	
5	I. K.	VII.	18	...	260	Ditto	Oostya ...	Bidaipore ...	.....	5	329	162.80	107.95	54.85	8.50	46.35	163273	3953	41.30	
6	N. O.	IX.	21	3	140	Ditto	Routrapore Hill	Domeparrah Hill ...	.....	7	330	152.69	105.50	47.19	17.35	29.84	206266	4968	41 52	
7	P. Q.	X.	23	1	...	Ditto	Daspore ...	Gouibank ...	1	1	356	149.80	94.34	55.46	21.40	34.06	169288	6315	26.80	
8	R. S.	XI.	24	6	420	Ditto	.....	Nyagaon ...	1	6	240	147.00	98.97	48.03	12.00	36.03	200144	9496	21.08	
9	T. U.	XII.	26	7	100	Ditto	Dewakote ...	Sydessur Hill ...	.....	3	348	142.88	34.23	108.65	76.00	32.65	123073	2359	52.12	
10	V. W.	XIII.	27	6	80	Ditto	Berhampore ..	Naraj	.....	4	100	137.86	70.23	67.63	40.00	27.63	112013	2599	43.10	
11	8 s. h.	XVII.	36	6	510	Ditto	Cheetinsin ...	Lt. Harris's, Cuttack	1	4	616	121.13	97.61	23.52	3.30	20.22	145687	8534	17.07	
12	a. b.	XV.	32	4	600	Katjooree	Cuttack ...	Chargurreah ...	1	2	510	131.22	96.15	35.07	4.30	30.77	131061	7125	18.39	
13	c. d.	XVI.	33	6	650	Ditto	Lalbagh, Cuttack	.....	1	0	327	127.13	86.13	41.00	11.00	31.00	106356	5646	18.84	
14	i. k.	XVIII.	...	...	...	Ditto	Kannuggur ...	Soobudrapore ...	.....	3	360	122.50	75.76	46.74	15.64	31.10	57934	2357	24.58	
15	e. f.	XIX.	...	...	...	Kokai	Kajeputna ...	Narainpore ...	.....	3	420	125.18	104.41	20.77	Dry	20.77	39500	2406	16.41	
16	l. m.	XX.	...	...	...	Beropa	Cheetursur ..	Fukeerparrah ...	.....	2	333	118.00	98.81	19.19	Ditto	19.19	22467	1661	13.53	

JOHN C. HARRIS, *Lieut.*,
In Charge Survey, Cuttack Rivers.

TABLE II.

TABLE showing the incline of the Mahanuddy Flood of A. D. 1855, *between various points at which high Flood-marks have been observed in season* 1855-56. *Distance measured along line of Mid Channel.*

Between what Places.		Distance apart.			Fall of Flood.	Average Fall per Mile.	Remarks.
From	To	Miles.	Furlongs.	Feet.	Feet.	Feet.	
* Bydessur ..	Bherah ..	6	2	100	8·43	1·34	
Ditto ..	* Chirchika ..	10	...	400	13·74	1·36	* At places
Ditto ..	* Ruttaghur ..	14	2	560	16·14	1·30	marked thus, the
Ditto ..	Soobunapore ..	16	2	400	18·63	·98	flood-marks are
Ditto ..	Oostya ..	18	...	260	20·53	1·10	evident to this
Ditto ..	Kandalpore ..	19	4	640	27·88	1·42	day, or they have
Ditto ..	Rowtrapore ..	21	3	140	30·64	1·43	been gauged as at
Ditto ..	* Paiksaye ..	26	2	400	38·68	1·49	Naraj, Lieutenant
Ditto ..	* Naraj ..	27	6	80	45·47	1·64	Harris's and Lal-
Ditto ..	* Lt. Harris's ..	36	6	510	62·20	1·69	baugh; other flood
Ditto ..	* Lalbaugh ..	33	6	650	56·20	1·66	levels are good
Bherah ..	* Chirchika ..	3	6	300	5·31	1·39	and taken from
* Chirchika ..	* Ruttaghur .	2	1	160	2·40	1·13	observations made
Ditto ..	Soobunapore ..	6	2	...	4·89	·78	directly after
* Ruttaghur ..	Ditto ..	1	7	480	2·49	1·31	flood of 1855 ere
Soobunapore ..	Oostya ..	1	5	520	1·90	1·15	the line of drift
Oostya ..	Kundalpore ..	1	4	380	7·35	4·67	was indistin-
Ditto ..	Rowtrapore ..	3	2	540	10·11	3·16	guishable.
Kundalpore ..	Ditto ..	1	6	160	2·76	1·55	
Rowtrapore ..	Daspore ..	1	5	520	2·89	1·68	
Ditto ..	* Paiksaye ..	4	7	260	8·04	1·63	
Ditto ..	* Naraj ..	6	2	600	14·83	2·33	
Daspore ..	Nyagaon ..	1	5	420	2·80	1·64	
Nyagaon ..	Dewakote ..	2	0	340	4·12	1·99	
* Paiksaye ..	* Naraj ..	1	3	340	6·79	4·72	
* Dewakote ..	Ditto ..	...	6	640	5·02	5·76	
* Naraj ..	* Lt. Harris's ..	9	...	430	16·73	1·84	Approxima-
Ditto ..	* Lalbaugh ..	6	...	570	10·73	1·76	tions merely;
Ditto ..	Doodhooa ..	34	4	430	55·56	1·61	heights taken
Ditto ..	False Point ..	67	4	430	91·11	1·35	from Trigono-
* Lieut. Harris's	Doodhooa ..	25	4	...	38·83	1·52	metrical Sur-
Ditto ..	False Point ..	58	4	...	74·38	1·27	vey.

JOHN C. HARRIS, *Lieut.*,
In Charge, Survey Cuttack Rivers.

TABLE III.

TABLE showing the Theoretic Discharges at various points in the Mahanuddy between Bydessur and Cuttack, calculated by Etelwyn's Formula ($V = \frac{9}{10}\sqrt{2\,f.\,d.}$) "f" being the Fall per mile between coupled Sections and "d" the mean of their Hydraulic Mean Depths.

Section of River.			Sectional Area as per Table I. Square Feet.	Hydraulic Mean Depth, as per Table I.	Mean Sectional Area of Coupled Sections.	Mean of their Hydraulic Mean Depth.	Fall of flood per mile between Sections.	Calculated Velocity.	Calculated Discharge in Cubic Feet per second.	Remarks.
Number.	Letter.	Plate.								
1	A. B.	III.	197904	24·56	213575	23·78	1·34	7·18	1533468	
2	C. D.	IV.	229246	23·00	227090	22·82	1·39	7·17	1628235	
3	E. F.	V.	224934	22·64	208077	30·37	·78	6·20	1290077	
4	G. H.	VI.	191220	38·14	177247	39·72	1·15	8·60	1524324	
5	I. K.	VII.	163273	41·30	184769	41·41	3·16	14·55	2688389	
6	N. O.	IX.	206166	41·52	187777	34·16	1·68	9·64	1810170	
7	P. Q.	X.	169288	26·80	184716	23·94	1·64	7·97	1472186	
8	R. S.	XI.	200144	21·08	161608	36·60	1·99	10·86	1755063	
9	T. U.	XII.	123073	52·12	117543	47·61	5·76	21·08	2477806	
10	V. W.	XIII.	112013	43·10						
								Total,	16179718	Giving average of 1797746

JOHN C. HARRIS, *Lieut.*,
In Charge, Survey Cuttack Rivers.

TABLE IV.

TABLE showing the Heights of various points in the Revetment Wall, above or below the Flood of the 29th July, 1855, as extracted from Lieutenant Harris's Notes taken on the following day.

Description of Portion referred to.	Height of Wall untouched by Flood. Feet.	Height of Flood Level above top of wall. Feet.
Commencement of Revetment East of Salt Golahs	2·89	
First angle beyond Revetment East of Salt Golahs ...	2·60	
Second angle beyond Revetment East of Golahs	1·99	
Curve short of Golah	2·81	
End of Golah Bastion...	3·22	
Angle beyond Golah Bastion (West)	2·26	
Second angle beyond Golah Bastion...	2·37	
At Ramp	2·02	
First angle beyond Ramp	1·47	
First angle of projection a-head	1·01	
Little Bastion...	·67	
Second Bastion (opposite Burgut Tree)	·38	
Angle beyond Burgut Tree	·01	
Angle short of steps	·08	
Angle beyond steps	·58	
Steps (by Fukeer's Tukya)	·48	
First Bastion beyond Fukeer's Tukya	·49	
Second Bastion beyond Fukeer's Tukya	·26	
Third Bastion beyond Fukeer's Tukya	·11	
Fourth Bastion beyond Fukeer's Tukya (Kutcherry Com-	.....	·19
Commencement of breach of 1854 ... [pound)	.....	1·12
Termination of breach of 1854	.....	·63
First Bastion of Collector's Kutcherry	·71	
End of Kutcherry	·90	
Commencement of second breach of 1854	1·58	
End of second breach of 1854	2·57	
Commencement of steps of Lalbaugh Compound	·91	
End of steps of Lalbaugh Compound	.....	·44
End of Lalbaugh Garden	2·05	
Commencement of steps beyond Lalbaugh House ...	·11	
End of steps beyond Lalbaugh House	·13	
Commencement of Buttress	·53	
Bastion at end of Buttrees	.....	·37
Bastion beyond Lalbaugh Compound	2·13	
Steps at Hurreree Ghaut	.....	·05
End of Hurreree Ghaut	.....	·05
Angle of Revetment beyond Hurreree Ghaut...	.....	·82
Bastion beyond angle of Hurreree Ghaut	.....	·63
Revetment beyond Bastion	2·07	
End of Bastion	·75	

The above Notes were taken by me on the 30th July, when the flood had fallen 1·25 feet above maximum level. To the observed level of day named I added, at each point, the height named, to obtain that of the day previous.

JOHN C. HARRIS, *Lieut.*,
In Charge Survey, Cuttack Rivers.

TABLE V.

TABLE showing the Surface Levels of the Mahanuddy and Katjooree Rivers as gauged on opposite sides of the Town of Cuttack, during the rainy season of A. D. 1855.

Date.	JUNE.			JULY.			AUGUST.			SEPTEMBER.			OCTOBER.		
	Reading of Gauges.		Difference.	Reading of Gauges.		Difference.	Reading of Gauges.		Difference.	Reading of Gauges.		Difference.	Reading of Gauges.		Difference.
	Mahanuddy.	Katjooree.		Mahanuddy.	Katjooree.		Mahanuddy.	Katjooree.		Mahanuddy.	Katjooree.		Mahanuddy.	Katjooree.	
1	.....	102·00	.....	103.38	102·00	1·38	.....	124·79	.....	109·19	113.66	4·47	105·44	105·54	0·10
2	.....	103·05	.....	103·70	103·05	0·65	.....	121·50	.....	108·19	112·41	4·22	105·19	104·85	0·34
3				105 35	105·33	0·02	113·03	118·00	4·97	107·93	112·00	4·07	.....	104·39	.....
4				106·34	107·58	1·24	111·19	116·00	4·81	108·86	113·33	4·47	.....	104·25	.....
5				106·61	108·25	1·64	109·45	114·00	4·55	109·09	113·58	4·49	104·00	103·75	0·25
6				106 80	108·79	1·99	108·19	112·41	4·22	109·53	114·00	4·47	103·84	103·33	0·51
7				107·50	111·08	3·58	107·32	110·75	3·43	108·99	113·50	4·51	103·63	102·83	0·80
8				107·06	110·16	3·10	106·85	109·00	2·15	110·55	115·16	4·61	103·41	102·33	1·08
9				107·53	111·25	3·72	106·34	107·58	1·24	111·59	116·20	4·61	103·11	101·91	1·20
10				106·87	109·08	2·21	105·34	106·58	1·24	112·12	117·00	4·88	102·95	101·58	1·37
11				106·27	107·50	1·23	105·47	105·66	0·19	113·83	119·00	5·17	102·80	101·25	1·55
12				106·48	108·00	1·52	105·22	105·00	0·22	112·93	117·83	4·90	102·72	101·08	1·64
13				107·36	110·00	2·64	.....	104·50	.....	111·12	115·79	4·67	102·64	100·91	1·73
14				108·46	112·75	4·29	.....	104·00	.....	110·18	114·70	4·52	102·60	100·83	1 77
15				113·03	118·00	4·97	.....	103·66	.....	110·01	114·58	4·57	102·98	100·68	2·30
16				113·45	118·50	5 05	.....	103·25	.....	112·62	117·58	4·96	102·94	100·60	2·34
17				113·38	118·33	4·95	103·67	102·91	0·76	113·28	118.33	5·05	102·63	100·50	2·13
18				110·75	115·41	4·66	.....	102·79	.....	113·83	119·00	5·17	102·74	100·37	2 37
19				110·43	115·00	4·57	103·67	102·91	0·76	114·41	119·56	5·15	102·71	100·25	2·46
20				111·68	116·41	4·73	.....	102·95	.....	113·45	118·50	5·05	102·76	100·06	2·70
21				111·18	115·83	4·65	105·22	105·00	0·22	112·28	116·75	4·47	103·27	100·87	2·40
22	.....	94·92	.....	111·74	116·50	4·76	105·49	105·75	0·26	109·91	114·58	4·67	103·58	102·56	1·02
23	.....	94·92	.....	111·97	116·75	4·78	106·17	107·33	1·16	108·29	112·56	4·27	103·42	102·16	1 26
24	.....	94·92	.....	112·10	117·00	4·90	107·09	110·25	3·16	107·59	111·33	3·74	103·22	101·75	1·47
25	.....	95·92	.....	112·41	117·33	4·92	110·28	115·00	4·72	107·08	110·20	3·12	103·28	102·00	1·28
26	.....	97·42	.....	112 63	117·58	4·95	108·63	113·00	4·37	107·02	109·37	2·35	103·43	102·50	0·93
27	.....	97·42	.....	112·93	117·83	4·90	109·79	114·33	4·54	106·59	108·27	1·68	103·43	102·41	1·02
28	.....	98·34	.....	.....	122·50	.....	112·02	116·83	4·81	106·27	107·50	1·23	103·55	102·66	0·89
29	.....	99·00	.....	121·13	127·13	6·00	112·41	117·37	4·96	105·96	106·91	0·95	103·85	103·58	0·27
30	102·80	101·25	1·55	.....	126·38	.....	112·24	117·20	4·96	105·71	106·29	0·58	103·94	103·58	0·36
31	.....	.....	.....	.....	125·25	.....	110·83	115·50	4·67	.....	.....	.....	103·67	102·91	0·78

Not observed. Not observed.

JOHN C. HARRIS, *Lieut.*,
In Charge of Survey, Cuttack Rivers.

COPY of a MEMORANDUM submitted by LIEUTENANT W. D. SHORT, *Officiating Executive Engineer, Cuttack Division, on the Cuttack Revetment and the Katjooree River, (dated Midnapore, 15th February,* 1855.)

SIR,

IN reply to Chief Engineer's letter, No. 1578, of 22nd August, 1854, and Superintending Engineer's memorandum, No. 2542, of 25th August, 1854, I have the honor to state that hitherto the authorities have not had the advantage of good surveyed plans of the Cuttack revetment and the public buildings, which are now submitted by me showing

First.—Both banks of the Katjooree river.

Secondly.—The actual set of the current after the successful experiment carried out by me to divert the great volume of water, and cause it to *set in* a channel parallel to, instead of nearly at, right angles to revetment.

Thirdly.—The public buildings along the crest of the revetment.

Fourthly.—The road or boundary (in rear of the revetment) along which the city houses extend.

Fifthly.—The portions or lengths of the revetment threatened, indicated by the length deeply shaded.

Sixthly.—The particular point of the revetment at present threatened, (vide breach No. 2).

Seventhly.—Sections showing depth of water under the revetment, with the height to which the flood rose this year, (1854-55,) and the level of the city 6 feet below this high flood line.

Eighthly.—The nature of the bed of the Katjooree river in front of the revetment.

2. On the above-mentioned points, I would beg to submit the following remarks:—

3. Without doubt, the body of flood water passed through the head of the Katjooree river at Ghurmotree, has (during the last eight or ten years) increased very considerably; this is evidenced by the prolongation of the spit of sand at the head of the Mahanuddy on its right bank, and in proportion to this extension, follows the narrowing of the Mahanuddy head; thus (vide annexed plan) the left bank of the

Katjooree at its head *a* has been yearly cut into, thereby widening the channel; and at the same time a deposit has been thrown up at *b*, narrowing the head-way of the Mahanuddy river.

4. At present the volume of flood of the Mahanuddy river, (immediately above the head of the Katjooree) is confined between two ranges of hills, within a rocky unchangeable channel; and just below the point, where this pent-up flood rushes through the gorge, (which is terminated by a hill called Ghurmotree) the Katjooree river is thrown off.

5. The right bank of the Katjooree at its head is rocky, and the channel very deep at all seasons.

6. The hill, at the head of the Katjooree (right bank) curves, so as to throw off the flood with the greatest facility; thus it will be seen, that there is a natural increasing tendency towards the enlargement of the Katjooree channel.

7. Moreover, until the flood rises sufficiently to top the sand hills on right bank of Mahanuddy,* and pass down the bed of that river, it necessarily flows down the Katjooree in excess, that is, it appeared to me during high flood (when standing on left bank of Mahanuddy, looking down the Katjooree), that as the flood was shot out of the Mahanuddy rocky gorge, ere the volume (intended for the main channel) could cross the breadth of the head of the Katjooree, the latter (Katjooree) received an undue volume, or before the spit at *b* could be acted upon, the high sand at *a* was being eaten into, and thus the Katjooree head-way increased.

* At C in Plan.

d a.

8. "*To regulating and controlling the flood at the head of these channels*" the attention of the Engineer should be directed.

9. *The cause is above,* and ignorance of the cause (I am of opinion) has been the reason of so many failures, and of so much anxiety, past and present.

10. Although the river was thrown off from the revetment by me, by means the most simple, I was, and am still of opinion, *that engineering efforts, scientifically applied, would regulate the volume in both rivers.*

11. Considering the rocky range on right bank of Katjooree river (at its head), it is but natural to hope for a similar foundation on

the left bank (although at a lower level) as a continuation of the range of hills.

12. Under any circumstances, I would propose an artificial spit (to be constructed of stone masonry) at the head of the river, vide Outline Plan annexed, whereby the flood, as it rushed through the range of hills, would be regulated at a point, where, at present, the greatest variation or change yearly occurs.

13. If the Katjooree channel is allowed to increase, there is not a doubt but that some great catastrophe will occur, and as my successor is a practical Engineer, and looks to the main point, viz. levels and sections, it will be as well to take advantage of his presence, to obtain the necessary information, with the view of ascertaining the advisability and practicability of the above-mentioned project.

14. At present I can see no difficulty in constructing a bold promontory of masonry, where material is so abundant and so near at hand; and if a rocky foundation cannot be found, wells might be readily sunk on which to carry up the outer walls, and the interior might be of rubble.

15. Should this project be favorably considered and acted upon, a great and wealthy district would be benefited and water-communication be opened to the sea.

16. The construction of the promontory of masonry *would* confine the Katjooree river (at its head) between it and the rocky range on right bank, and thereby lessen the volume acting in the river against the revetment, which would then be less liable to being breached; *(the revetment must always be liable to be breached, considering it has no foundation, and the rush of the flood is always direct instead of parallel to it)* thereby also the difficulty of preserving the Southern Division of Orissa from the yearly increasing floods, would be lessened.

17. The decrease through the Katjooree head, would increase very considerably the volume on the Mahanuddy, the bed of which would be well able to receive the extra volume poured therein, which would tend to scour and deepen the channel, and render it perhaps navigable (for a greater length) for cargo boats throughout the year.

18. *Again, if means be not taken to regulate the flood at the head of the Katjooree river,* the danger to the Southern Division of Cuttack will be incalculable, because for a series of years the right bank of the river from its head to village of Chargurreah (originally very high and

above flood level) has been eroded, and now the flood pours over it, in addition to carrying away great portions.

19. The result of this action now is, that the flood comes down upon the Khoordah road, and the drains thereon (which were never intended to pass it off) are swept away, or left isolated, and the road is enormously breached.

20. This known evil is small in comparison to the great probability of the Katjooree leaving its bed opposite the revetment, and taking to the channel of the Kokai, which would inevitably flood the Southern Division; and if this occurred, (I am of opinion) it would breach the line of embankment on left bank of Bargovee at *, running parallel to the Coast, find its way into the Summugrah Jheel, and thence through the present small channel viâ Pooree (instead of the Chilka Lake) into the sea; when the Bargovee, with the direct communication with the sea, might become a tidal river to a greater extent.

21. A simple examination of the right bank of the Katjooree opposite to the revetment, (above the head of the Kokai) will satisfy (by levels) the correctness of the above statement, which is made after a careful and minute examination during high-flood.

22. The plan submitted will show how important to the safety of the revetment, was the success of the experiment undertaken by me.

23. The project was a simple one, economical and very successful, although thought little of (indeed, I believe, scarcely acknowledged).

24. I can, however, confidently state that it was the means of saving the town; for the main river, which flowed during the extraordinary season of 1854-55, upwards of 73 feet deep under the Collector's house, (and the Collectorate a little lower down), was thrown off and coaxed into a channel 5 and 600 feet distant, thereby preventing the occurrence of a breach at this threatened locality, which might have swept the Collector's house and Kutcherry with all the Government records away.

25. Had the same principle been sanctioned and carried out, there is every reason to suppose that the channel might have been continued and made to run parallel to, and distant from, the lower

* Where the Bargovee, after running due South, turns suddenly at right angles, and flows parallel to Coast line.

part of the revetment, to where the Government Salt Golahs are situated.

26. I conceive any attempt to force the stream by expensive measures, viz. "forming immense stone break-waters in the sandy bed" *as so much money thrown away,* for the velocity of the current meeting such an obstruction will inevitably undermine it; and the whole, after one season of flood, will disappear, having served no useful purpose.

27. The means to be adopted are, to commence work immediately on the fall of the river, coax the low water current by embanking with sand, protected by jhamps and brush-wood, which (whilst they *give* to the stream) collect deposit, deepen the channel, and then at the point where the embankment nearly meets the head of the new channel *(into which it is intended to divert the stream), there* to sink one or two large boats; thus the new channel previously excavated, will (during several months) become accustomed (so to speak) to the gradual flow of the low-water current, and be consequently a more ready recipient of the heavy flood when it arrives, and this is what occurred in the experiment undertaken by me.

28. The situation of the public buildings on the crest of the revetment must, under any circumstances, be critical, and deserves the serious consideration of the Government.

29. It is a fatal error to suppose, because the buildings have been hitherto saved, that there is the less fear of their going at any moment.

30. What can be expected where the foundations are liable, at any moment, to be undermined?

31. Where breaches occur above and below, it is a mere piece of good fortune that the buildings are not breached, indeed with such a contingency, considering the consequent certain loss of life, destruction of public records, (not to mention the impossibility of repairing any enormous breach in one season, owing to the failure in the supply of materials,) it would be provident to prepare for such a possibility, by selecting a more suitable spot for the erection of a Collectorate.

32. This measure might be facilitated by the Government calling for a return of the expenditure (for a series of years) in endeavouring to patch up the revetment, when it will be doubtless discovered that the amount would have paid for a new Military and Civil Station, as well as remuneration (if such was requisite) to the householders, in the event of the revetment being breached and the town flooded, or for a new town.

33. The portions or length of revetment threatened (vide the Sections), afford convincing proof of the uncertainty of the permanency of any part; and what bad policy it is to await the occurrence of the evil, *as also the inexpediency of attempting any remedial measures with the revetment, without first adopting means to regulate the volume at the head.*

34. The river channel, through which the river was coaxed, merely tended to avert the danger *for the time* from the most important point, viz. that along which the Collector's house and the Kutcherry and the other civil buildings are situated; and the site of No. 2 breach proves, that had the channel been carried on for another half a mile, the main current would have been distant from the revetment, probably causing a great deposit of sand to be thrown all along its base.

35. The sections of the river's bed will show how great is the volume of water that has to be contended against, and this *difficulty* is increased, when the velocity with which this volume rushes through the rocky range (5 miles above) is remembered.

36. It is true, that whilst the flood lasts, there can be no breach, but when it falls, the great lengths of the revetment breached, without the necessary materials to repair them, before the probable arrival of the next flood necessarily increases the danger, obliging the Officer to expend money, in many cases, to no good purpose.

37. To provide against every contingency, so great a supply of stone would be required, that the cost (now that it must come from a distance of many miles, the stone in the Cuttack Fort having been expended) would be enormous; and if the estimate were now called for, the Government would immediately find that the town and cantonments were not worth the outlay, inasmuch as it would, under the existing state of things, be an *annual one.*

38. Finally, I am of opinion that, as a temporary measure, money might be more usefully expended (even if it amount to 12,000 or even 20,000 Rupees) by cutting or continuing the channel commenced by me, so as to coax the main current away from the revetment, and thus, by lessening the danger, afford time to the Government to have the whole subject thoroughly considered, with the view of coming to some satisfactory conclusion, viz. either to undertake remedial measures of a permanent nature, or if this would be too expensive, to remove the public buildings and the cantonments to a very fine rocky site on the left bank of the Mahanuddy river, where stone might be quarried at very little expense, and in great abundance.

N. B.—I would remark with reference to Chief Engineer's 3rd paragraph, that I am of opinion, that blocks of stone are not procurable in sufficient abundance to form a break-water base to the slope proposed in 1848, and if they were, labour would not be available to carry out so extensive a project in one season.

As regards the work executed by Lieutenant Hunter, whether it was bad or not, I cannot form an opinion; all that can be said is, that the blocks did not appear as if they over-topped each other sufficiently, but at the same time I think it my duty to remark that no work, even the very best, could avert a similar catastrophe, when there is but a sandy foundation, ever liable to be undermined by particular sets of the current.

From the Superintendent of Embankments, to the Chief Engineer, Lower Provinces,—(No. 1439, dated Midnapore, the 24th September, 1855.)

SIR,

I HAVE the honor to acknowledge the receipt of your letter, No. 3196, dated 19th September, 1855, calling for an outline of the project we have in view, to control the floods of the Mahanuddy, and of the circumstances which make it necessary that Lieutenant Harris should be relieved of the duties of which he is at present in charge, in order that he may give his undivided attention to that river.

2. As my proposition was to relieve Lieutenant Harris of all other work, in order that he might the more quickly acquire the information necessary for the formation of a complete project for controlling the Mahanuddy floods, it is clear that I am not in a position to state what those works shall be, nor their extent, nor, in fact, to make any report on the subject in the absence of the information* it is so urgently necessary that the Executive Engineer should obtain, and which he feels he cannot properly obtain with justice to the subject and to himself, if he is constantly to be employed on other duties, which must be the case whilst he is Executive Engineer of the Cuttack Embankments.

* Capacity of Mahanuddy channel, levels to the sea by both branches from the rocky gorge. Possibility and expense of widening the gorge by removing the left bank, and thus directing the waters to the left bank down the Mahanuddy branch.

3. But I can state the case generally and refer to the Madras works for illustration. The Mahanuddy, before it divides into two branches, discharges itself through a rocky gorge, having formed above this place a large basin for its waters proportioned to the size of the neck, which obstructs the free passage of the floods. The floods, having lost their velocity in this basin, start afresh through the neck and act upon the right bank below it, and have formed a large bay, which has widened the head of the Katjooree branch, the shortest line to the sea; and the consequence has been, that as the Katjooree head has increased, sand-banks have been thrown up below it in the Mahanuddy branch, further diminishing the head of water that flows down that river, which has a much greater capacity lower down than the Katjooree has, although the bed is becoming raised.

4. What the Katjooree is to the Mahanuddy, the Coleroon was to the Cauvery river before the grand masonry weir was constructed across the head of the Coleroon, regulating the discharge by that branch, and forcing a fair supply of water down the Cauvery.

5. The works undertaken by the Madras Government had for their object, the irrigation of the lands in the Cauvery Delta, and it was requisite to balance the supply of water, so that the Cauvery should have sufficient to irrigate the lands dependent upon it for cultivation. This was a sufficient object. The works have been constructed; have proved, after many alterations and experiments, entirely successful; and the outlay has been amply repaid, the returns to Government being 23⅓ per cent. on the capital invested, and the District that was going to ruin having become, beyond example, a happy and prosperous one.

6. We have these works to guide us, and the experience gained in their construction should secure our operations being effective and successful; but it may be asked what the objects are for which Government should undertake the construction of such great and expensive works on the Mahanuddy river.

7. There is the city of Cuttack, situated in the fork of the two branches, having its stone revetment standing on the sands of the Katjooree many feet above the level of the lowest part of the channel, which may, at any time, be turned against any point of its length, many parts of the city being below the level of the Katjooree flood rise. There is the country dependent on the Mahanuddy branch, and on the many channels it throws off in its length, for water for its cultivation,—land richly cultivated and in many parts thickly peopled.

There are the rich lands on both sides of the Katjooree, which is called the Dail river in its lower course, and has numerous branches forming islands which are also well cultivated. There is the rich district of Pooree, which, in the present state of the Mahanuddy, is in the greatest danger. If the Kokai river, which is the first and largest branch thrown off by the Katjooree, could have contained its floods a little longer, and have directed them fairly into the Bargovee and Dya branches, I believe that the native prophecy of Juggernath being washed into the sea would have been fulfilled this year.

8. This saying of the natives is, I think, to be noted; as it indicates that during some flood of former years, there was danger of the event happening.

9. The Revenue Board can inform you of the remissions made in Central Cuttack during the last ten years. I know that in Pooree they have exceeded 1,50,000 Rupees; and that for the last year only, the remission was above 50,000 Rupees.

10. The evil is a progressive one, and has been allowed to go on too long. The balance of waters must be maintained; the Katjooree must not be allowed to drain the Mahanuddy, and the bed of the Mahanuddy must be cleared and kept at its proper level, which can only be done by shutting out the excess drain of the Katjooree and forcing the waters down the Mahanuddy.

11. It will be a short-sighted economy to postpone operations of the nature required, and to expect an officer whose time is occupied with other affairs to give the consideration really necessary to this great question, which has already superseded, in Lieutenant Harris's mind, all interest in his embankment duties, to which, however, I am obliged to tie him down, whilst he has charge of the Cuttack Division.

12. Not to accede to Lieutenant Harris's urgent desire is virtually to postpone the works. He asks merely to be allowed to apply himself exclusively to this subject, until he is able to place his plans and project in a complete shape before Government.

13. I have for some time been in correspondence with the Commissioner, Mr. Samuells, on this subject, and in his last demi-official letter he says, "I have no doubt that the problem of the Cuttack rivers "is to be solved by an anicut across the head of the Katjooree."

14. On the subject of the irrigation of the Cuttack district, Mr. Samuells says in the same letter, "We want sets" of levels along the

Mahanuddy and Katjooree, and from the right banks of these rivers to the sea, very much indeed; until we have these, and they must be very carefully taken by men on whom you can rely, we can say nothing of the practicability of irrigating the waste lands of Pooree and Cuttack from these rivers.

15. I shall now ask the Commissioner distinctly, with reference to your letter, whether he thinks Lieutenant Harris should be detached to give his entire attention to the Mahanuddy.

16. The danger of delay on a matter of this kind is that, the very next rains, the city of Cuttack may be destroyed, and the villages in the low lands of Pooree and of the Katjooree river swept away, whilst the bed of the Mahanuddy is further deteriorated.

17. The Coleroon project, to which I have before referred, was shown to be feasible in 1830, the plans were matured by 1834, and laid before Government with Colonel Cotton's Reports of the 29th January, 15th and 17th July, 1834, the Collector signifying his entire approval of the project, which had been matured in constant communication with himself, in a letter dated 6th of August, 1834.

18. The final sanction of Government was granted in 1836, and between February and April of that year the works were completed.

19. I may add that I addressed Lieutenant-Colonel Baird Smith, knowing that he had visited the Madras irrigative works for the express purpose of working up the information to be obtained from them into a Report, and that he has expressed his views on the subject generally in favour of weirs of stone across the heads of channels as the best means of regulating the discharge of a river by its branches, citing examples in Madras; and that he subsequently very kindly furnished me with a copy of his Report on the Delta of the Cauvery.

20. A stone weir cross the Katjooree head is the first great work to be constructed. It will then, I think, be necessary to place a weir across the Kokai head, for it is not desirable to shut up the Katjooree.

21. The works, you will observe, are not undertaken for the purpose of making the Mahanuddy a navigable river; this, however, will be a subsidiary project that will follow on the deepening and clearing out of the river channel. I may state here, with reference to the remarks in your letter, that I have read Calver on Harbours and Tidal Rivers, and that I have in my library the Parliamentary Report of the Commissioner appointed to enquire into the present state of the

River Tyne, which has very valuable remarks on the subject of the mouths of rivers, so that the importance of admitting as great an influx of the sea as possible, is not likely to be lost sight of in prosecuting works connected with the navigation of the Mahanuddy.

22. But I repeat, that this is not the object of the great works at the Katjooree head, which are undertaken, supposing them eventually sanctioned, for the purpose of distributing the floods and passing them off without destroying the cultivated lands of Pooree and Cuttack.

23. If, in doing so, we can make the Mahanuddy navigable, it will be an additional advantage, and a very great one.

24. I beg you will contrast the Commissioner's remark respecting the necessity of having accurate levels of the Mahanuddy's course to the sea, with the following observation recorded by Lieutenant-Colonel Baird Smith in his Report on the Works in the Cauvery Delta:—

"Strangely enough I have not been able to find on record a single "longitudinal section of the beds, either of the main stream or of the "branches; the distribution of slope is, therefore, not so precisely "known as it ought to be."

25. We must avoid this error; but how can we work precisely, unless we have accurate information, and how can we procure accurate information, unless we have time to devote to the work of collecting it. We are commencing upon a series of large works, and the Officer, who is to be entrusted with their execution, should be able to apply an undivided attention to them.

The first and most important point to establish is, the capacity of the Mahanuddy Channel.

26. Lieutenant Harris is a capable, energetic Officer, and has become interested in the consideration of these measures; directly he sailed into the Mahanuddy basin at the entrance of the Bankee estate and had seen the rocky gorge that limited the river, he felt that the reins were in his hands, and that the Mahanuddy could be guided into a course that would save the Provinces of Cuttack from destruction. Is it too much to ask that this subject shall be considered so important as to require immediate consideration, and the whole of an experienced Executive Officer's time, energy and attention?

27. I would ask you, if this matter be allowed to go on in ordinary course, when it may be expected that the works will be commenced and finished?

From the Superintendent of Embankments, to the Chief Engineer, Lower Provinces, Fort William,—(No. 1599, Midnapore, 8th October, 1855).

SIR,

IN continuation of my letter, No. 1439, dated 24th September, 1855, and with advertence to the second paragraph of your letter, No. 3196, dated 19th September, 1855, I have the honor to submit a copy of a letter just received from Mr. Samuells, Commissioner of the Cuttack Provinces, on the subject of the importance of Lieutenant Harris's devoting his whole time and concentrating his attention upon the circumstances of the Cuttack rivers.

2. I may state another important subject of inquiry for Lieutenant Harris in his new capacity of Ex-Engineer of the Cuttack rivers and lakes, which is the high level of the Chilka lake at the period of the year when the sea level is low, causing inundations in the Pooree district from floods that might, if the Chilka level were reduced by increasing its discharge, be carried off without overflowing the country.

From E. A. SAMUELLS, ESQ., Commissioner, to CAPTAIN J. P. BEADLE, Supdt. of Embankments, Midnapore, Commissioner's Office, Cuttack Division, Cuttack,—(No. 287, the 2nd October, 1855.)

SIR,

IN reply to your letter, No. 1477 of the 26th ultimo, received this day, I have the honor to state that I consider it very desirable that Lieutenant Harris should be relieved from the details of the Cuttack Office and embankments, and employed in making a comprehensive survey of the rivers of the province, and taking their levels and those of the country between Cuttack and the sea, with a view of discovering a remedy for the double course of inundation and drought from which the province now periodically suffers.

2. The embankments of this division have been constructed piecemeal, without the sightest reference to any general series of levels or to any fixed principle. There is no doubt that, owing to this mode of proceeding, great mistakes have been made, and large sums are wasted every year in keeping up embankments which ought never to have been erected.

3. It appears very probable that by throwing anicuts across the heads of some of the rivers and improving the channels and the outlets of all, we may be enabled to dispense with three-fourths of the embankments in the district, and may, at the same time, obtain data for a system of irrigation which would greatly increase the productive resources of the country, and as a necessary consequence, the Government revenue.

4. There is little doubt also that a work of the character I have mentioned at the head of the Katjooree would effectually protect the city of Cuttack from the danger which has threatened it during the past two years of being destroyed by the river; but before a work of this nature is undertaken, it is obvious that a very minute knowledge of the Katjooree and Mahanuddy rivers and the country likely to be affected by diverting the water to the former into the channel of the latter, is absolutely necessary, and this, it is impossible that Lieutenant Harris can acquire, if he is burdened with the duties of the Cuttack Office.

From CAPTAIN C. B. YOUNG, Officiating Chief Engineer, Lower Provinces, to the Secretary to the Government of Bengal, Fort William,—(No. 3656, dated 19th September, 1857.)

SIR,

I HAVE the honor to submit herewith the Report* of Captain W. D. Short, the Officiating Superintendent of Embankments in Bengal upon the causes of the frequent breaches in the bunds of the Cuttack Province which was called for in your No. 1143, dated 20th March, 1857.

* Superintendent Embankments letters No. 963 dated 3rd August, 1857. With accompaniments in original, copy of Superintendent of Embankments, No. 1204, dated 28th Aug., 1857.

2. It may be divided into two distinct portions. The first, embracing as far as the 33d para., explains how far the breaches are due to the Executive Department since the year 1840. The second, including the remainder of the report, explains to what extent they may be ascribed to natural causes which have been for some years in operation at the head of the Delta of the Mahanuddy at Cuttack, and which have had the effect of throwing an undue proportion of flood waters into the Katjooree river, and thus subjecting the bunds in southern Cuttack to an undue pressure, which they have been unable to resist.

3. The two subjects may be considered, as indeed they are, distinct from each other. The following table will show the Executive Officers,

with exception of one or two, who have held charge for a few days or a month or two only at unimportant periods, who have been in charge of the Cuttack Division since the year 1840.

TABLE I.

Dates of Change.	Names.	Rains of	Working season of	Number of Breaches.
	Captain Rigby ...	1840 to 1848	1840-41 to 1848-49	45-46 322 46-47 54 47-48 91 48-49 204
February 1849 to May 1850...	Captain Macleod	1849	1849-50	 8
May 1850 to March 1851.....	Captain Abbott ...	1850	1850-51	 0
April 1851 to November 1851	Captain Rigby ...	1851	April & May 1851	 95
November 1851 to May 1852	Captain Hunter ...	„	1851-52	
June 1852 to January 1853 ...	Captain Sanson ...	1852	Nov. & Dec. 1852 / 1852-53	 1167
January 1853 to October 1854	Captain Short...	1853	1853-54	 942
	„ „ ...	1854	1854-55	 878
December 1854 to Jan. 1856	Captain Harris ...	1855	1855-56	 1365
January to October 1856	Segt. Raynor... ...	1856	1856-57	 404
October 1856 to June 1857	Segt. McGuinness	Central		
	Segt. Raynor	Southern		

The next Table will shew the expenditure on the bunds of central, southern and northern Cuttack from the year 1840 to the present time taken from Captain Short's annexed document A.

TABLE II.

Table of yearly expenditure on the Cuttack Embankments.

1840-41,...	27,721	11	8	
1841-42,...	10,109	15	4	
1842-43,...	19,250	2	8	
1843-44,...	21,317	8	6	
1844-45,...	20,215	12	3	
1845-46,...	32,122	13	10	
1846-47,...	15,791	13	10	
1847-48,...	18,929	8	9	
1848-49,...	20,132	7	11	Total 1,85,591-14-9 average of 9 years Rs. 20,621 5 2.
1849-50,...	3,979	10	10½	
1850-51,...	1,664	11	7¼	Total 5,584-6-5¾ average of 2 years Rs. 2792 3 2.
1851-52,...	20,401	1	8	
1852-53,...	17,317	5	8	
1853-54,...	33,891	14	0	
1854-55....	56,682	1	7½	
1855-56,...	1,20,789	6	9¼	
1856-57,...	57,576	12	9	Total 306,658-10-5¼ average of 6 years Rs. 51,109 12 5.

4. A third Table will shew the remissions of Revenue in Cuttack extending over the same period, viz. from 1840 to 1857. The information which Captain Short has given on this head not going beyond the year 1842, I have applied to the Board of Revenue to be furnished with a table of the remissions of Revenue in Cuttack, central and northern, and Pooree (southern Cuttack), from 1831 to 1856 : this has not yet been received, but will hereafter be submitted in continuation of this letter.

5. From these tables and from Captain Short's Report, some idea may be formed of the system in force under certain Officers, whose prescribed instructions and system are known ; also of the extent of the protective measures adopted and carried out by them, and of the results which ensued yearly in the province, commencing from the year 1840.

6. It would appear that at first, from 1840 to 1848, there was a long period (and the only instance of it during the interval under consideration) when the embankments of the whole province were under one Executive Engineer, Captain Rigby. During this time the orders and intentions of Government were clear to maintain the bunds in full and efficient order. Captain Rigby accordingly spent, on an average, 20,000 rupees yearly, on the maintenance, repair and improvement of the bunds, and was allowed (included in this) a sum of 15 rupees a mile for petty repairs.

Twenty thousand.

Fifteen.

7. Captain Short speaks of Captain Rigby being respected and his name remembered with gratitude in the Province; and next to Captain Rigby, Captain Short is the Officer who has had the longest and best experience of the division. Captain Short states his opinion that the breaking up of a good system began from the date of Captain Rigby's departure. Nevertheless the province was not without its troubles. It would appear from Captain Short's table A that the year 1840 was one of famine; 1841 and 1842 years of drought; 1845-46 and 1848 of inundation. Of the intervening years 1843-44 and 1847 there is no record.

(Remarks on the change of Officers para. 1, Captain Short's letter.)

8. At this time, viz. 1847, the question of abandonment of river bunds altogether was entertained, and the Military Board issued orders in their No. 3181, of 1st March, 1847, "prohibiting all but the repairs neces-

Captain Short's para. 7.

sary to prevent actual breaches, for such time as the question of abolition or retention of bunds was under discussion."

9. In the working season of 1847-48, 18,929 Rupees were spent and in 1848-49, 20,132 Rupees under Captain Rigby, which is about the usual previous average. In 1849-50, under Captain Macleod, Engineers, and 1850-51, under Captain Abbott, there were spent yearly only 3,979 and 1,604 Rupees respectively, or an average of 2,792 Rupees. Both these years are described as years of drought.

10. In April 1850 (just before he resigned charge in May to Captain Abbott) Captain Macleod wrote his No. 412 to the address of Colonel Sage, Superintending Engineer, submitting his estimate for repairs for the current year 1850-51, amounting to Rupees 2,032 only, and with it a statement of "useless or fictitious" bunds in Northern Cuttack, to which it was intended to give no repairs, and to strike off the list of bunds under charge of the executive officer.

11. In August succeeding, Captain Abbott with his No. 159 of 26th August, sent an enlarged list of a similar description, giving all the useless bunds in the three divisions of north, south and central Cuttack; and from this, it would appear that 438 miles out of a total of 774 were struck off or "swept away," as Captain Short says in his 11th para. of report and 3d para. of remarks, vide also 2d para. of No. 1204 of 28th August where he says, "Not even patch-work was resorted to, but the bunds were left unrepaired."

12. How far Captain Short is correct in describing this proceeding as "a breach of faith," or, in adducing previous Commissioners of the district, viz. Messrs. Ricketts and Mills in his support, I am unable to say; but he lays considerable stress upon it, as will be seen from the 8th and 9th paras. of his Report, and again in paras. 21 and 25 and distinctly repeats in para. 5 of his No. 1204, that Messrs. Ricketts and Mills had recorded their opinion that Government were "bound to keep up the embankments;" and as regards its effect on the embankments, he briefly says in the conclusion of the 3d para. of his remarks that "neither the office nor the embankments have recovered from "the shock."

13. It is to be noted, however, that both those years were years of drought, and that as far as can be judged from the return of remissions, there were remissions in the first year 1849; and in the succeeding year (1850), as well as that following (1851), they were very

small. In 1852, when the inundations began, which have continued to 1857 and will be hereafter adverted to, the remissions became at once very large.

14. In April 1851, Captain Rigby, Engineers, rejoined from his leave, but remained only during the rains until November, chiefly employed in bringing up his accounts.

15. One working season, viz. that of 1851-52, under Lieutenant Hunter intervened, before Captain Short took charge. During this year 20,401 Rupees were spent. There is no record of the country suffering from either drought or inundation in the year 1851. But the year 1852 was one of heavy inundation, and the number of breaches in the embankments which had, in previous years, at the most not exceeded 200 or 300 now amounted to 1167.

16. The consecutive seasons of neglect previous to the rains of 1852, which Captain Short describes as 4, but which were in fact only 3, viz. those of 1849-50, 1850-51 and 1851-52, under Captains Macleod and Abbott and Lieutenant Hunter, had "left the embankments," Captain Short says in his 24th para. "in a state which baffles all description," and he describes the Superintending Engineer as writing to enquire "why the embankments were in such a disgraceful state," and desiring "to know the cause of the breaches."

Captain Short's para. 25.

I can find no reason why Captain Short regards 1851-52 as a year of "neglect," when 20,401 Rupees are said to have been spent on the embankments, nor why again in the 2d, 3d and 4th paras. of his No. 1204, he speaks of 5 years of neglect, alluding to the years 1847 to 1851 inclusive, when in 3 of these years, viz. the 2 first and the last, as much as 20,000 Rupees yearly was spent on the bunds. But in paras. 4 and 5, of his No. 1204, he very distinctly repeats that from 1847-48 to 1851-52, (he having joined at the beginning of the working season of 1853,) the orders in force from the Military Board and Superintending Engineer were, "to abandon one half, and not repair efficiently the other half" of the embankments.

17. Captain Short then came into office in January 1853, and during the remainder of that working season and the following one of 1853-54, he held charge. There was an average of 25,000 Rupees yearly spent on the bunds during these 2 years. They, that is the rainy seasons of 1853 and 1854, were both years of heavy and extraordinary inundation, and the breaches amounted to respectively 942 and 878, in each year.

18. It seems at this time to have required the whole energy and powers of the department merely to close the breaches, and strengthen as much as possible the bunds in the places where they were weak; so much so that Captain Short thought the time allowed by the ordinary working season too short, and describes himself as commencing his labour (para. 28,) "early and previous to sanction." He appears to have been so far successful that the number of breaches diminished to 942 and 878, although the river continued each year in a high state of inundation. In the year 1855-56 the work of filling in breaches had increased to such an extraordinary extent that it actually amounted to so much as 26 miles of new embankment averaging 10 to 15 feet in height. This was after the rains of 1855, when there was the largest number of breaches on record, viz. 1365.

Para. 32.

19. From this time up to the present, the orders in force on the Cuttack embankments have been merely to fill in breaches, Captain Short alludes to this frequently; in his last letter No. 1204, para. 6, when he was in charge; para. 7, under Lieutenant Harris; para. 8, under Sergeant Raynor, and lastly para. 10, under Sergeant McGuinness.

20. In para. 11, and the annexure to his letter, he gives more distinctly the tenor of those orders, in an extract from a previous letter of his No. 246, dated 26th May, 1857. In this he says that the orders issued by the Chief Engineer and approved by Government in November 1855, were that "no work was to be carried out in the Cuttack division except breach filling, and that the utility of this measure even was doubtful; indeed that positive instructions could only be given when certain information was provided from the results of the survey and levels to be taken by Lieutenant Harris."

21. In answer to the distinct question put to him by me, why the embankments have deteriorated from 1847 to 1857, in spite of increased expenditure on them in late years, his reply is (paras. 12 and 13) "that to this neglect," viz. the orders alluded to in the last para. "is the increased number of breaches to be attributed, and that he believes no better or truer reason is to be assigned." He also states his opinion (vide para. 16,) that no blame is to be attached to the Executive Department.

22. Captain Beadle the Superintendent, and the Executive Engi-

neer, without exception, he describes, and I believe truly, as having been most zealous and conscientious in the performance of the works entrusted to them, but the embankments having once been suffered to fall into disrepair, indeed the one half of them having been deserted or given up altogether, it became a work of very considerable difficulty to restore them to their previous condition.

23. The difficulty of this task was greatly increased by two circumstances, one which has been already referred to, viz. the waiting for the result of Lieutenant Harris's extensive series of levels and his expected Report on the Mahanuddy river. The other the yearly deterioration of that river's bed above Cuttack, whereby increasing volumes of its flood waters were annually thrown into the Katjooree, its southern, to the detriment of the Mahanuddy proper, its northern breach.

24. The latter subject attracted, from all interested parties, increased attention every year, because not only were the south Cuttack embankments and bunds subjected to increased pressure and disaster by every successive flood, but because the existence even of the city of Cuttack itself, appeared to be threatened.

25. The remainder of Captain Short's present Report from the 33 to 54 paras. is exclusively occupied with this subject, and he has, on numerous other occasions, written and reported largely upon it. It has been the same with the other Officers concerned in the matter, and a volume of their reports and plans has already been published by the Government during the present year, forming Part I. of the expected Report from Lieutenant Harris.

Brought from the Bengal Office by Captain Short in the last month.

26. I may here state that Lieutenant Harris having been ordered on field service, and the manuscript of the second part of his Report not having, as I understand, been commenced yet, but the plans to accompany being ready or nearly so, I have directed them to be submitted alone, as soon as possible, as it appears to me that the interests involved in the submission of this Report to Government, and the decision of the question are of far too important a nature to be deferred longer, or to be put aside to await the uncertain return of Lieutenant Harris.

27. At the same time I must confess that I approach the subject myself with very considerable diffidence, the problem under question being no less than the "control of the Mahanuddy," a river discharging in the rains 1,800,000 cubic feet per second above the city of Cuttack,

or more than 3 times the volume of the river Hooghly. Such is the avowed object stated throughout the reports of Captains Beadle and Short and Lieutenant Harris and such in fact it is.

28. These Officers all appear to have come to the conclusion that a masonry weir, or weirs of some kind are necessary in the bed of this river, with a view to apportion fairly between the two rivers, Katjooree and Mahanuddy, and therefore between the southern and northern parts of the Cuttack provinces, the enormous body of flood waters which this great river brings down in the rainy season; and probably from their long and intimate acquaintance with the province and the subject, they may be fully justified in their opinions.

29. But I must confess that I, who have but a small local experience compared to theirs, cannot so readily arrive at this conclusion. I will endeavour briefly to explain the aspect which at present the question bears to me, premising only what I believe the Government will not fail to observe, that the decision of so important a question as the "control of the Mahanuddy" by Engineering works involving the expenditure of very large sums of money, for a purpose, the compensating advantage of which yet remains to be fully proved, is one which cannot yield to those of the large rivers in the southern Presidency the Kistnah, Godavery and Cauvery, and is one which will require the best Engineering advice and experience in their power, to be given to it.

30. The object in view with the Madras works is irrigation. There is no such object here. What there may be hereafter I know not, but I believe I am right in taking the 74th para. of Captain Beadle's report as the true exposition of the object in view in all the designs now submitted. He says "The works projected have one single object, to restore the equilibrium of the channels by clearing out the raised bed of the Mahanuddy, reducing the discharge by the Katjooree, and causing the Beropa outlet to resume its original importance as a channel of relief." In no part of the reports is irrigation systematically treated of as the object in view, indeed Cuttack being within the influence of the South West monsoon, and its crops consisting almost entirely of rice, there is not, I believe, the great demand for it that there is under the different circumstances of the Madras Provinces. But in this I may be wrong. That the country suffers from drought as well as inundation is beyond question, and I

(The Beropa is an off-shoot of the Mahanuddy, Cuttack.)

am far from saying that artificial irrigation, if it could be obtained, would not be desirable.

31. Although the object of the Madras works is irrigation, yet in the case of the Cauvery we find there was another object intimately connected with it, which was exactly similar with that described by Captain Beadle. "On contrasting the physical condition of the two branches," (viz. the Cauvery and Coleroon) Lieutenant-Colonel B. Smith writes we find "accordingly on the one hand, a larger volume, a more rapid slope, and a more direct channel than in the other. The natural result of such a combination, is the progressive deterioration of that branch which is less favorably circumstanced, by the formation of deposits at its head, and the consequent diversion of the great body of the main stream into the superior channel. For nearly 25 years from the time at which Captain Caldwell's works were completed, an incessant struggle was maintained against the increasing tendency of the river bed to silt up; the head and many parts of the channel were periodically cleared of deposits by manual labour; long and expensive embankments were carried across the bed of the main stream, so as to force a larger supply of water into the Cauvery branch. All these efforts, however, were ineffectual: the bed continued to rise, the supply to diminish, the extent of land under irrigation yearly decreased, the revenue was falling off, and the condition of the people was visibly becoming "worse and worse."

32. The result eventually was, that success was obtained by building directly across the mouth of the Cauvery a similar dam to that which was originally built across the mouth of the Coleroon. These two dams then, it will be understood, were across the mouths of the two rivers where they separated from each other.

33. I believe the results of experience in this case may be safely taken as some indication of what would be the consequence, were works such as are now projected carried out in the Mahanuddy. The surplus water which causes so much anxiety by passing down the Katjooree, would, I apprehend, after a lapse of time be found to be flowing down the Mahanuddy, and would cause equal anxiety and equally fatal results there; and there would be no remedy for this, until, as in the case of the Cauvery, another dam was thrown across the Mahanuddy at its head for the purpose of directly regulating its waters.

34. If I am right in contemplating this as the eventual result,

whatever may be now designed or constructed should be done with that end in view. The weirs that are now proposed, are none of them designed on this principle. They are laid down at different angles with the stream, and not in the shortest line directly across it, nor reaching from one bank to the other the whole way, as the Madras anicuts do. Their purpose is quite different from them, and their operation will also, I am of opinion, be so.

35. The Madras anicuts are built directly across the stream at right angles, and their result is to dam up the stream altogether in a large and quiet pool, from which the water is either drawn off for irrigation, or runs to waste over the weir.

36. In the other case (the Mahanuddy) considerable portions of the main channel being still left open, there will be a large escape and a consequent current of water above the weir, as explained by Captain Beadle in his 71st para. "There will be a scouring action along the foot of the dam." With the anicuts the invariable result, as Lieutenant-Colonel Smith writes, is to silt up the river-bed above the dam. Here there will be a "scouring action," and how far that will extend, it is very difficult to say.

37. The dry weather volume of the Mahanuddy is not very great certainly, but whatever it may be, its rapidity and velocity may be expected to be increased, in the channel at the tail of the dam where its escape is permitted, and the left bank being capable of erosion the stream will probably enlarge its bed in that direction, and finally leave the Katjooree without any dry weather stream whatever, a deprivation which could not fail to be felt at Cuttack itself, and in the southern country. It would either do this, or it would by the scouring action alluded to, undermine and destroy the dam, and return to the Katjooree as before, in either case baffling the efforts to control it.

38. Lieutenant Harris allows in his estimate 50 per cent. for "sinkages and repairs" in the first few years; and Captain Beadle adds a front apron as well as a rear one, which is not usual or necessary with the ordinary Madras anicuts. I fear these provisions would be insufficient, and that as long as any action or motion of the water were permitted on the upstream side, and at the extremity or tail of the dam, the eventual and inevitable consequence would be undermining and ultimate destruction of it.

39. The fears I have ventured to express apply, I regret to say,

to all the projects proposed, which are marked clearly in the accompanying map, and I could not myself conscientiously recommend any expenditure upon them, still less of such a sum as six lakhs of Rupees, as estimated by Captain Beadle.

40. If irrigation be proposed, and be considered of more advantage than the navigation of the Mahanuddy, which would of course be obstructed above Cuttack by any dams constructed there,—if in short anicuts or weirs are to be constructed, I would propose that they be constructed exactly upon the Madras model, in a direct line across both streams, at their divergence, from bank to bank.

41. If the control and regulation of the quantity of water in the two rivers be the only object, I am of opinion that the most certain means of effecting it would be by such dams or anicuts.

42. If the expense of such works be considered inadvisable or disproportionate to the benefits to be derived, I would recommend that operations of a temporary and more inexpensive nature be resorted to, such as Captain Short has tried already with advantage on two or three occasions in different rivers, and particularly in the Katjooree. These consist of brushwood spurs or dams, and excavations of initial channels in the sand bars which obstruct the channel, and combined with efforts which, in my opinion, might be made during the time of partial flood, when assistance from the river itself can be derived to open out new channels, these would I think be successful in effecting the desired good.

43. I have said that I have approached this subject with diffidence, and I deeply regret that I am obliged now to submit an opinion on it which I am necessitated to do, without that full knowledge of all its details which so important a subject no doubt demands. Nevertheless I am personally acquainted with the river and the country, and as the subject of operating upon Indian rivers is one in which I have for some time taken a deep interest, I am not altogether unprepared for it.

44. In a memo. submitted by Captain Short on the Cuttack river and Katjooree river, dated 15th February, 1855, I find him writing, para. 26, "I conceive any attempt to force the stream by expensive "measures, viz. forming immense stone break-waters in the standing bed, "as so much money thrown away, for the velocity of the current meeting "such an obstruction will invariably undermine it, and the whole, after "one season of flood, will disappear, having served no useful purpose."

45. I confess I am of this opinion, and think that these permanent dams can only be constructed in the manner of the Madras anicuts and other waste weirs, which being built quite across the stream, present no extremity upon which the current can act mischievously, and over which high floods roll innocuously, because in the up-stream side there is dead water and no current, and on the lower side a broad and deep apron of stone to avert the destruction which otherwise the commotion of the water rolling over the dam would certainly cause.

46. The return of the original enclosures is solicited when no longer required.

From CAPTAIN W. D. SHORT, Officiating Superintendent of Embankments, Lower Provinces, to the Officiating Chief Engineer, Lower Provinces,—(No. 953, Midnapore, dated 3rd August, 1857.)

SIR,

IN reply to your letter, No. 1938, of 6th July, 1857, and agreeably to letter, No. 1143, of 20th March, from the Secretary to the Government of Bengal, requesting me to submit a full report on the "causes of the numerous and constantly occurring breaches in the "embankments of the Cuttack district, and to take immediate measures "for the prevention of the recurrence of similar evils," I have the honor to report, that I proceeded to Cuttack on the 30th May, 1857, where I conferred with the Collector of Cuttack, as suggested by the Board of Revenue, and endeavoured to point out to Mr. Shore the causes and the proposed remedies, and beg herewith to annex my report on the subject.

REPORT.

In order that the Government may arrive at a correct conclusion on the subject of the protection afforded to the district by embanking, it is necessary to trace the history of the system, shew the causes of the existing evils, and endeavour to point out the remedies.

1. The Province is subject to seasons of extreme uncertainty, and liable to the most remarkable vicissitudes of drought and inundation (as remarked by Mr. Moffat Mills the former Commissioner.)

2. The system of maintaining the embankments prior to the year 1840, must have been very inefficient, because no Executive (except Lieutenant now Lieutenant-Colonel Fraser, who was a few months in the Koordah or Southern Division) had been qualified to exhibit a section of an embankment, much less to dispose of the earth sanctioned for repairs. Cutting trees, up-rooting jungle, removing huts, improving curves, sloping banks, &c. had never been attempted, and where such ignorance and inefficiency prevailed, the evil effects may be guessed at.

Prior to 1840.

3. It will be well to bring forward the calamities to which this Province had been subjected, prior to the date of the new settlement, in order to shew the interests at stake, and the necessity of controlling the waters of the Mahanuddy river, to prevent inundation on the one hand, and on the other to give its quota of water for the purposes of irrigation in all seasons of drought.

In 1834-35, the country was laid waste by inundation, and Rs. 1,86,942 of the Revenue remitted.

Rs. 1,86,942, Inundation.

In 1836-37, severe drought desolated the Province, and Rs. 4,52,532 were remitted.

Rs. 4,52,532, Famine.

In 1837-38, a similar calamity occurred, causing a remission of Rs. 5,87,146.

Rs. 5,87,146, Famine.

In 1840-41, in the Cuttack Collectorate *only*, the remission from want of water and failure of harvest amounted to Rs. 3,73,107.

Rs. 3,73,107, Famine.

In 1841-42, for similar reasons, a remission of Rs. 2,09,290.

Rs. 2,09,290, Drought.

In 1842-43, for the same cause and early cessation of periodical rains, a remission of Rs. 4,86,625 (to the whole Province) was granted.

Rs. 4,86,625, Drought.

Thus, during a period of 9 *years*, there were remissions of Revenue (owing to either inundation or drought) of *nearly* 23 *lakhs* of Rupees or 2½ lakhs a year, the interest of 50 lakhs of Rupees at 5 per cent.

It is needless to dilate on such a state of things.

4. The present settlement was made on a sufficiently liberal scale to allow of the zemindars bearing all ordinary losses, but in all extra-ordinary seasons the river has been allowed to devastate to such an extent that the settlement could not stand the test, necessitating remissions; a table of which I regret I have not yet been able to

provide, but which the Collectors of southern and central Cuttack might be requested to prepare, as such would make the information very complete.

5. In 1840, Captain Rigby took charge of the Cuttack division, and from 1840 to 1845, the condition of the embankments continued to be a highly improving one, because this Officer brought great ability, zeal, and energy to bear upon all he undertook. As already recorded, the seasons of 1840-41, and 1842-43, were years of drought (and consequent heavy remission) and the floods in the rivers do not seem to have supplied the deficiency of local rain, (or the embankments would have been cut) Captain Rigby's foresight, however, led him to take advantage of the low water level in rivers to strengthen the embankments against the surely expected inundations. Moreover, in addition to the annual expenditure on passed estimates, he had the advantage of the sanction of 15 Rupees per mile for petty repairs, (which superseded the order which allowed "work to be done, even to the extent of 2 annas, *only* on "actual inspection of the Executive Officer," which order was necessarily a dead letter when brought to bear upon 600 to 900 miles of embankments).

1840 to 1845.

6. The annexed table of expenditure will shew that Captain Rigby steadily prosecuted the repair of the existing lines and, as far as was consistent with the change of system (as recorded in 7th para.), he carried out the principle up to the date of his departure on sick leave in January 1849, or during a period of 8 years.

7. From 1845 to 1849, the efficiency of the embankments must have deteriorated very considerably, because orders were passed by the Military Board, vide their letter, No. 3181, of 1st March, 1847, prohibiting *all* but the repairs necessary to prevent actual breaches while the question of "abolition or retention" of embankments was under discussion.

1845 to 1849.

8. Now this order *was nothing more or less* than stopping the annual repairs, and considering that the Government were bound to keep up these embankments, in order to secure the Revenue (which fact ought to have been well known, as it had been urgently pressed by Messrs. Ricketts and Mills), such an order was a breach of faith, tending to disorganise the prevailing system, and so weaken the then existing

sections of embankments, that they were, for the future, readily breached by any flood more than an ordinary one, and consequently topped and breached heavily in all *extraordinary* seasons.

9. The repeated discussions as to the retention or relinquishment of embankments tended not only to stop all annual repair, but all necessary work, and every kind of improvement; so that, when a crisis came, the damage done could not be remedied, as the labour available in the district was only sufficient to carry out the ordinary annual repairs; therefore the discussion should have ceased when no change could be made during the pending settlement *without breach of faith.*

10. Captain Rigby's energy had worked a great change for the better as evidenced by the many fine works visited by me in detail, and which had stood the test of so many years of neglect; however the system even previous to 1845 was rotten, for it protracted the repairs necessary in one season, to be carried on in the next and following one, and by persistence in this ruinous system, the embankments could never attain efficiency, as portions could only come under repair once in ten years, thus, in a climate like Bengal, where the work was tried by local rain and floods, improvement to any wholesome degree, was a hopeless task.

11. Captain Rigby's state of health required a change, and in January 1849 he left on sick leave, when Captain Macleod took charge, who, with a desire to economise, but with a hasty and unsound judgment, supported by Lieutenant-Colonel Sage, (the then Superintending Engineer) swept away, by a stroke of the pen, nearly one half of then existing embankments as fictitious and useless,* and in the same spirit expended little or nothing on what remained, as evidenced by the annexed table of expenditure.†

1849 to 1851.

* Vide annexed statements. B.

† Statement of expenditure. A.

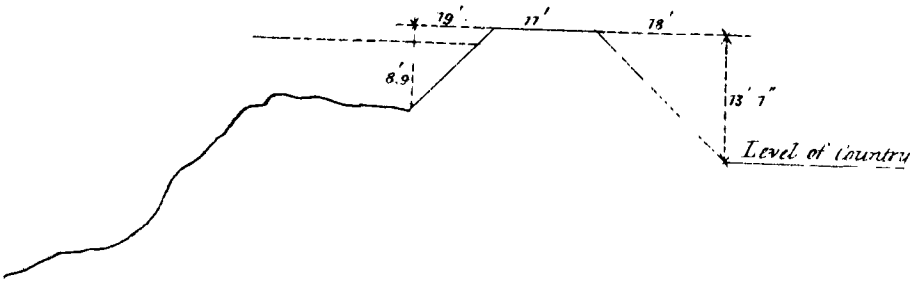
12. It is almost needless to point out, that the utility or otherwise of 900 miles of embankment and the agreements on which they were constructed and repaired, required something more than the knowledge obtained in a single visit in the dry season by an inspection of but a small portion, and many of those of minor importance. A thorough knowledge of the localities in *extraordinary*, as well as *ordinary*, seasons of flood, with a list in detail as given in the settlement papers of the

Revenue Officers, *is*, and *ought to be*, the only practical test, and when it is considered that the subordinates take the cue from the Executive's turn of mind, the deterioration of the embankments cannot be wondered at, and however hasty the Officer may have been in his conclusions, I would, whilst giving honor to Lieutenant-Colonel Sage's economical principles, doubt the sanity of that advice, which, on *insufficient data*, allowed a province to be laid open to inundation.

13. It is (as above stated) with a practical knowledge of floods, and data from the Revenue authorities on the subject of agreements, that an Executive or Superintendent can alone furnish the length of embankments it may be the duty or interest of the Government to keep up.

14. One point, however, ought to be thoroughly understood and impressed upon the minds of all, in order not to be forgotten, viz. that no list of embankments can be permanent, as long as the banks of rivers are not so, and these are from time to time eroded, according to changes in the bed of river, or sets of the current caused by the removal of large sand deposits; which leads me to endeavour to explain the history or origin of the connected lines of embankment now seen along the banks of several rivers.

15. The long connected lines of embankment now seen had their origin doubtless in isolated pieces, and as the high ground between these was eroded, necessity involved the connection of the disunited lengths, to illustrate which, I would refer to section.



Suppose the highest flood level on the bank to be within 1 foot of crest, the land protected by it would be 12.1 below the flood level. Imagine the country crossed just above it to be 9 feet higher than where the section is shewn, it might still require an embankment equally with the lower country, although one of smaller dimensions.

16. Assertions made by Officers are worthless (as to the utility or otherwise of embankments) and must be so, as long as visits are paid during the dry season, the levels of the successive inundations on the river banks unknown, the river banks liable to erosion and natural embankments (or protection afforded by great drifts of sand or deposit settling at various localities) subject to removal.

17. There are but two practical ways of gaining correct information whereon to found an opinion that can be of use to the Government to act upon, the first is taking longitudinal sections along either bank of river from head to mouth (which process is very tedious and without establishments a source of procrastination), the second (the mode adopted by me and which led me to understand the subject) to visit leisurely, and with consideration, the entire district during high flood level, when the sets of current are made known, with the water-mark sharp and clear, affording a practical test of the line of levels.

18. Considering how little the subject of embanking has been taken up as a study, and the few who have taken the trouble to watch the action of the floods at high level, it is not to be wondered at, that *extreme* opinions are held on the subject, one party believing embankments injurious, and desirous of doing away with them, whilst others believe, that extreme strengthening of section of embankment will (by confining the flood, and causing it to scour its channel) prevent breaches.

19. The enemy feared by cultivators *is not water,* but the strong and violent currents sweeping every thing before them (when allowed to pour down over the fall that is to be found *inland* from the banks of all these great rivers) and the attendant *deposit of sand,* and wherever an embankment wards off these evils, and sluices are given to assist irrigation, the people and the Revenue must be benefited.

20. Again, as water is required in seasons when the river flood does not top the bank, the local rain is retained within large tracts (to fertilise the land) by embankments, which in this way are of benefit.

21. The mistakes made by hasty judgment in such important matters, have already cost the Government much, and heavy expenditure will be required to remedy the neglect of so many years. Breach of faith to the landowner, was committed in 1847, when the annual repairs were stopped, and the opportunities for doing good can never well be recovered under the present system; and breach of agreement was also committed during the two years in which (with no heavy floods) nothing was done, owing to the advice given by Officers of inexperience.

22. Thus, during the seasons of 1849-50 and 1850-51, little or nothing was done, and one-half of the mileage of the embankments had been struck out as useless by Captain MacLeod. Captain Rigby rejoined from leave for 6 months (merely to bring up arrears), when he left a charge in which he met with confusion and opposition, and wherein the works carried out by him for the benefit of a district (in which to this day his name is revered by the landowners, who, after all, are the best judges of efficiency), had been neglected.

23. During 1851-52, Lieutenant Hunter, a young Infantry Officer was in charge (pending the seizure of some Engineer who might be induced to take the Cuttack Division) and he did his best till June 1852, when Captain C. B. Young was appointed Executive Engineer, who came down, remained 22 days, and left for Burmah, when Captain Sansom, an Infantry Officer held charge for 6 months, or during the flood season of 1852-53.

1852-53.

24. Four continuous seasons of neglect, viz. 1849-50, 1850-51, 1851-52 and 1852-53, during which six Officers' names are found on the list) had left the embankments in a state which baffles all description, when the heavy floods of 1852-53 breaching the embankments in 1167 *localities*, devastated the district.

25. In January 1853, I joined as Officiating Executive Engineer, and, in proportion to the urgency of the cry of the Revenue Officers and landowners, came takeeds from the Superintending Engineer enquiring, "Why the embankments were in such a disgraceful state," "the cause of the breaches, &c. &c." whereas, had the records been studied, it would have been discovered (as I ascertained after gaining a practical knowledge of the district and studying the records), that the heavy responsibility lay at the door of the *authorities themselves*, who had, by positive orders, put a stop to protective measures by

breaking faith with the landowners, and finally by discussing the retention or relinquishment of the embankments (when the Revenue depended by agreement on their efficient retention), gave a death blow to the system, which otherwise, under calm and able management, might have benefited the district.

26. I found, during a careful inspection, that the head and neck of the embanking system had been destroyed, and the trunk weak and inefficient, and that with corrupt and ill-paid working Darogahs, and with no supervising *establishment*, a heavy task had devolved upon me.

27. In the hope that the heavy flood season of 1852-53, might be followed by a moderate one, and that by energy the difficulties might be faced, protection by closing up breaches was deemed the first duty, and (where time admitted of it) strengthening weak sections at all important localities; moreover, the working charges of the establishment were revised throughout, to the satisfaction of the Board and authorities; but the system had received too severe a shock to recover itself, and with neither time nor labour available, the weak points could not be strengthened, and in 1853-54 the flood season was again heavy, breaching the embankments in 942 localities, many of which, however, were in localities not visited, and doubtless included breaches of former years.

28. With a knowledge of the district, the system of working, the labour available, and the volume of flood to contend against (which yearly increased towards the south and south-east), I determined to commence work early and prior to sanction, and not only to close the breaches efficiently, but to strengthen every important point, and such work was accordingly carried out, when the floods of 1854-55 rolled down the Mahanuddy and Katjooree rivers.

29. The flood level was the highest on record, (although since exceeded by that of 1855-56,) topping the revetment in many parts, and only kept out by unceasing labour by day and night (by means of sand bags and stone work), and the embankments which had been strengthened were breached in 878 places.

30. The Mahanuddy and Katjooree floods met below the station, and finding their way through the Budja Kawat sluice, the town was threatened with an inundation similar to that of 1828, and as the level was 6 feet below the *then* high water mark the danger was very serious. The height of the flood, its duration, and the danger to the town and

the embankments, was increased many fold from the fact of a terrible gale opposing the pent-up volume, which was lashed into a sea during a continuous period of 42 hours.

31. During such a terrible visitation, the danger was averted by the assistance afforded by the Collector, Mr. R. Harrison, who gave the prisoners for the work, whilst the populace slunk panic-stricken within their houses.

32. Disastrous as were the results of the flood season of 1854-55, (considering that a strong gale prevailed during the period of high level of water) the breaches were less in number than in 1852-53 and 1853-54, proving that much had been done by me to strengthen weak parts ; this, however, afforded me little or no satisfaction as I had become convinced of the bad policy (so ruinous to the interest of the Government and the prosperity of the landowners) of spending money in merely filling breaches and strengthening embankments, or rather working when the *effect was produced,* instead of *counteracting the cause of evil.*

33. During my incumbency I had the whole weight of the old Cuttack Division on my shoulders *(since broken up into 6 charges, and now under 6 separate Officers*)* with heavy arrears of predecessors' accounts, and beg to refer to annexure letter C. with the view of satisfying the Government that *I* did my utmost.

C.

* Lieutenant Harris.
Mr. Rayner.
Mr. Boyce.
Mr. Armstrong.
Captain Dixon.
Lieutenant Bose.
(Balasore Division.)

34. I would, however, here record, that whilst deeming it a duty to close breaches, other more important and permanent measures were either proposed or carried out by me, viz. :

1*stly.* In January 1853, in order to lessen the impending danger to the Cuttack revetment and city, which consisted in the deep pooling of the flood along and under base of the Cuttack revetment, I specially recommended a system of continuous break-waters of brushwood, to arrest deposit, and thereby fill these pools, urging that the brushwood would offer little or no obstruction to the current, and would arrest the sand, mud and weeds, that the work was very simple to carry out, very economical, and that in one season the whole might be completed. This project, so practical, was unnoticed, nevertheless the very same measure was adopted by Lieutenant Harris in 1856-57, (3 years later)

and has been attended with the success predicted by me. Simple, economical, practical, and *timely* remedies are rejected when proposed, and tenfold expenditure thereby necessitated, not to mention the evil results to public works from the delay.

2*ndly*. In 1853-54, the whole volume of the flood impinged against the revetment at right angles (and that too at a point the most dangerous). When I submitted a project to turn the channel, divert the floods, and cause them to rush parallel to and at a distance from the revetment, the measure was, not approved of, (I believe) but strongly recommended by me to Mr. Ricketts (during his tour at Cuttack) to whom I explained my views. The work was then allowed, and accordingly carried out, by first cutting a new channel, then damming the low water current and diverting it therein, whereby the great flood in the Katjooree of 1854-55, rushing through the new cut, thus became (as may be seen to this day,) the main channel. The success and importance of this project was duly recognised by the authorities. (It is true that a breach occurred in the Hur Hurree Ghaut in 1855-56, but this I predicted must happen, because the revetment had been badly built up over a former breach prior to my taking charge.)

3*rdly*. I urgently pleaded the necessity of continuing the channel through the sands and carrying it below the Salt Golahs, whereby *that* portion of the revetment below the Cutcherry would have, ere this (together with the aid of brushwood operations), been protected, instead of remaining, as it is, exposed. However, this practical and economical measure was not attended to, and there is not a doubt in my mind but that good would attend its execution.

4*thly*. Again, perceiving that the volume rushing (viâ the Katjooree) in the Khoukhye, was yearly increasing, with no possibility of its finding vent, and thereby swamping the southern or Pooree Division, I projected an escape for the floods from Bargovee into the Sur Lake, vide annexure D. moreover in order to save a very valuable property worth about 2 lakhs on the left bank of the Koosbudder river (southern Division) where thousands of rupees had been expended in an attempt to oppose the current, I cut a new channel, and caused the floods for the future to flow therein, the old channel silting up.

D.

5*thly*. The above measures only benefited particular portions of the district, and were therefore limited in their effects, a careful exami-

nation, however, of the channels at the head of the Mahanuddy Delta (in 1854-55,) at low water, and during high flood level, convinced me thoroughly that all measures (of whatever description) carried out below the Delta must afford but temporary relief (and were therefore a source of useless expenditure to the Government, and of no benefit to the district) and that *the key to the whole question of reopening the Mahanuddy channel to receive its proper volume, making it navigable,* preserving the district from the fearful visitations by inundation and drought, was to be found in "*controlling the waters of the Mahanuddy river at the head of the Delta.*"*

* Vide annexure E.

35. *I originated* the project, proposed the remedial measure, and raised a warning voice (in January 1855), to point out the probable destruction of Cuttack, and devastation to the southern and south-eastern districts from the ravages of the floods, unless immediate measures were taken to prevent the yearly increasing volume passing down the Katjooree, and as no means were taken, the prediction was unexpectedly though terribly fulfilled in 1855-56, when the highest flood on record breached the embankments in 1365 localities (carrying away in the aggregate twenty-five and a half miles of embankment), devastated the central and southern districts, breached the revetment, and would have inundated the town had portions not been raised by me the year previous (as reported by Lieutenant Harris).

Twenty-five and a half.

36. Thus I have pointed out that during the seasons of 1849-50, 1850-51, and 1851-52 the floods were trifling, and caused little or no damage to the embankments, (for which reason these were entirely neglected) whereas, during the following seasons of 1852-53, 1853-54, 1854-55, and 1855-56 the floods were excessive, indeed in the latter season had reached the highest level on record on the Katjooree guage.

37. The season of 1856-57 was an ordinary one, the level of flood being several feet below that of former seasons, the duration at its highest level was, however, protracted, and the damage done consisted in 404 breaches.

1856-57.

38. The state of the embankments at the present moment may be readily guessed from the fact, that as the breaches increased in number and size, the greater became the difficulty to close them, leaving neither time nor labour to strengthen the weak sections of what

remained: thus it may be fairly pronounced that from the year 1847 to 1857 (or during a period of 10 years) the embankments of the Province have deteriorated, for the several reasons afforded by me, and the greater portion of the expenditure incurred has been money sunk, and that little or nothing has been done to advance the *permanent* security of the district.

39. However great may have been the injury in the deterioration of the protective works, it is *small* in comparison to what I conceive to be THE evil, in the lowering (by the increased scour) of the level of the bed of the Katjooree, and the consequent silting up of the great Mahanuddy river.

40. In January 1855 I predicted this would happen, and in 1857-58 I find, on inspection, the head of the Katjooree taking in the whole of the low water current and its bed *so scoured* that the low water level is 2 *feet below* all former ones, whilst the Mahanuddy, the main stream, is, for the *first time on record, entirely dry,* (water extending in it but a few hundred feet below the head of the Delta) with its bed proportionally raised, and the difficulties of re-opening it increased *a hundred fold.*

41. Whilst the main volume of flood found its way in 1855-56 down the lowest level, devastating the south and south-east of the district, the rise of the bed of the Mahanuddy caused the flood to stop and breach the embankments on the Mahanuddy and its escape to an enormous degree, (the latter having silted up proportionally.)

42. Ignorance, in the first instance, on the part of the authorities of the root of the evil, and inattention to the fact of the yearly increasing floods to the south and south-east; and latterly, indecision (when the root of the evil was pointed out and the remedy urgently pleaded) have brought about the most unfavorable results, and as the extraordinary level of the high flood of 1855-56 in the Katjooree, cannot be looked upon as a *maximum,* where the level is lowered and the spill increased; it behoves the authorities to come to some early decision, and direct the executive to act thereon, otherwise a catastrophe will occur, (in the natural course of events) compared with which all former evils will be considered unimportant.

43. The key to the future safety and prosperity of the district was given by me in January 1855, it was a point regarding which there could be no doubt, and although I strongly urged the necessity

of levels and surveys, *such* were not absolutely needed to determine whether or not the volume of the flood should be controlled at the head of the Delta. As I stated the Mahanuddy was fully equal to receive the whole flood (whereby its channel would be scoured and rendered more easily navigable), every project tending to secure this desirable object should have been unhesitatingly sanctioned and immediately carried out.

44. The Superintendent of Embankments, Captain Beadle, also saw the necessity of diverting the current into the Mahanuddy, and made a proposal for a weir, the heel of which was to extend from below Naraj. Now this project was either *good* or *unfavorable;* and if the latter, it behoved the authorities to substitute a better; whereas nothing was done but a sanction obtained, vide annexure F. Submitted with my letter, No. 534 of 30th June, 1857. No. 1970, of 24th November, 1855, (after the visitation by flood) to stack stone, to be brought into use; "as the Government required a well-considered report, before proceeding further than the above preparatory step."

45. In studying the records of the correspondence on the subject of the stacking of stone at Naraj (vide copy annexed for easy reference), I come to the conclusion, that Captain Beadle, fully alive to the urgency of the case, and seeing how he was trammelled by his own project being left undetermined, whilst no better one was forthcoming, directed Lieutenant Harris to carry out the work by "stacking the stone in the shape it would eventually assume," which order was met by active measures under Lieutenant Harris."

F. Submitted with my letter No. 534 of 20th June, 1857.

The Chief Engineer in his No. 3176 of 11th November,* 1856, apprised the Superintendent that "the Government of India had given no sanction for the material to be brought into use;" whereon the work *ceased,* and nearly another year has passed, and another flood is expected, and still the needful measure is delayed.

A year later.

46. Now as regards the spur or weir, one point is quite certain, that *until the project which meets with the greatest favour from the authorities* is sanctioned, the spur *must* do good; *for the further the high water level at the head of the Delta is diverted, or held up, in the*

direction of the Mahanuddy channel, the greater the scour in that channel, and proportionally *less will be the high water level down at Cuttack,* (the object being, to prevent the direct spill and consequent increase of volume immediately below Naraj), therefore the spur should be continued, and this I have ordered on a conscientious conviction of its utility.

G.

47. The fall in the low water level at the head of the Delta, and within the narrow rocky gorge, has led to a discovery of importance; for on arrival at Naraj, I crossed the river, conceiving there might be natural spurs of stone, which extended in a sloping direction a long distance into the bed, necessarily deflecting the flood towards Naraj; thus, (it may be for centuries,) there has been (in addition to the natural wear and tear of the rocky boundary under Naraj)* a constant action† tending, year after year, to divert the flood down the Katjooree. Again below the gorge, I found a similar but very extensive rocky spur on left bank, which has materially tended to break the otherwise direct alignment to Berhampore.

* (Right bank.)

† (From left bank.)

48. I immediately ordered blasting operations as far as practicable, and the removal of the stone by boat to add to the spur below Naraj. It is a practical measure, and I trust it will be sanctioned and orders given to carry out, after this flood-season, a systematic course of blasting and removing all the rocky obstructions for the more easy flow of the Mahanuddy.

49. Time does not admit of it at present, but hereafter I would cut a channel through the head of the Mahanuddy sands at a lower level than the bed of Katjooree, and cause the low water current to flow therein by closing the head of the Katjooree channel, by means to be hereafter described.

50. The great mistake hitherto made is inattention to deposits of sand at the head of the rivers and their escapes, as also in their beds, as such have an evil tendency by causing particular sets of the current, whereas by levelling these at a trifling expense, incalculable benefit would be derived.

51. On reconsideration of the subject of controlling the waters at the head of the Delta, I beg to offer for immediate attention the following measures.

1st. That operations on a large scale be commenced (after the

flood season) along the left bank of the Mahanuddy river from the Dompara hill (the commencement of the narrow rocky gorge) to Berhampore, to remove by blasting or otherwise the masses of projecting rocks which have hitherto tended materially to divert the current to the south, into the Katjooree, and also impeded the passage of the Mahanuddy flood in its direct and natural pathway.

2ndly. That similar operations be carried out below Berhampore at the Temple and Faqueers' island, indeed wherever the rock obstructs the Mahanuddy current.

3rdly. That from the head of the spit of the sand below Naraj, at *a*, a channel be cut* (length to be ascertained by state of bed after floods) through the sand, to receive the low water current, and eventually the high flood, as they are shot out of the rocky gorge at Naraj.

* With its bed lower than that of the Katjooree.

4thly. That the low water current of the Katjooree at its head be dammed by means of brushwood &c., &c., *c* to *d*, and from *d* to *b* (where the depth is greater) by means of vertical floats (to be hereafter described), to rear of which floating brushwood would be placed to create a deposit, when the the stone weir to rear of all will dam the current. This can be done economically.

5thly. That attention be paid yearly to the state of the channel at the *head* of the gorge between the Sedaissur and Dompara Hills, as *the* point *whence* a *proper direction* may, by judicious measures, be given to the pathway of the current; for instance, in 1855-56, under Sedaissur Hill a sounding was taken, shewing the extraordinary depth of 80 feet (or 16½ deeper than the mean level of the sea) whereas at *present* in (June 1857 as seen by me) this great chasm has been entirely closed, and the channel filled by a great deposit (vide survey taken of the locality) which deflects the current to the opposite or left bank, and thence by reason of the natural (rocky) spurs down the Katjooree.

6thly. That the channel cut by me in 1854-55 through the sand, in the bed of the Katjooree, opposite the town of Cuttack (and which is to this day the pathway of floods) be continued to below the Salt Golahs, by measures similar to those employed by me, and the same time brushwood be ready to place at intervals in the channel under and along the revetment, to cause the pools to silt up by accessions of deposit.

7thly. Lastly I would urge an early decision on the most important point, viz., the measure whereby "the volume of flood is to be controlled at the head of the Delta." Any obstruction within the rocky gorge, or above, would, I conceive, tend so materially, not only to throw back the floods in the higher reaches of the Mahanuddy as to cause considerable injury, but would decrease the impetus at the head of the Delta, and thereby lessen the scour which is so necessary for the purpose of clearing the silted up bed of the main river. Should the project brought forward by me in January, 1855, viz., the construction below and opposite Naraj (vide position marked in Lieutenant Harris's lithographed surveys) of a flêche of masonry founded upon the rock or wells, and backed by rubble work, and extended if necessary to Dooblessur or the Temple island, (to confine permanently the flood at the head of the Katjooree, and at the same time by a gradual sweep lead the Mahanuddy floods down towards the Temple island) be not favorably considered, then I would advocate a dam or weir founded upon wells (in front and rear) extending from Naraj hill in a gradual sweep down to Dooblessur or the Temple island, which would effectually confine the Mahanuddy flood and cause it to flow deeply under left bank (where the alignment is so good). This line would be about 9,000 to 10,000 feet in length, and whilst the scouring action of the current would deepen the bed all along the left bank of river, it would, I conceive, at the same time throw up the sand to a level with the crest of the continuous stone weir, whence there would be a spill to the south down the Katjooree, and the floods would make for themselves many channels through the waste of sand, when their velocity (and the danger to the revetment and country) would be considerably modified and readily controlled.

52. It would be inopportune to canvass in this letter the detail of the work suggested to be carried out, as we have the experience of similar works in the Madras presidency, with the cheering certainty of success.

It is sufficient that the root of the evil has been pointed out by me, as also the point undeniably settled whereat remedial operations should be vigorously carried out; and in earnestly soliciting the immediate attention of the authorities and the Government, to the early consideration of the subject, with a view of arriving at a final decision, I would conclude by remarking on the great natural advantages at

hand to assist us in the prosecution of the work: stone and timber in abundance, labour, if well remunerated, available to any amount, and in 3 to 5 years an energetic officer, unfettered with accounts, would give the Government a return for the outlay by opening a communication for the conveyance of the produce of the higher reaches to the Delta, the development of the mineral wealth of the hill districts, the waters in the escape, regulated at their heads by a system of dams, the navigation opened to the coast, and a cessation to the periodical visitations by inundation and drought, which have hitherto been the rule in a district, which ought to be a garden of fertility.

Herewith I beg to annex memorandum, wherein I have to point S. out the causes of the evils existing in the embanked districts of Cuttack, and suggested remedies, and with reference to the number and extent of breaches of the seasons 1854-55, 1855-56 and 1856-57 that were left open, the annexed docket K. with K. remarks, provides the necessary information.

I have, I trust, shewn that it is the system, and not any particular individual, that is at fault; also what I conceive to be the only practical remedy.

The measures proposed by me must first be canvassed by Engineers of experience, their opinions should be recorded, when the correspondence may be sent through the Commissioner and Collector of the district for the final decision of Government.

In order to shew that I have founded my opinions on a practical knowledge of the district, I beg to annex dockets L. M. N. submitted by me in November, 1854.

B.

From Captain N. C. McLeod, Officiating Ex-Engineer, Cuttack Division, to Colonel W. Sage, Superintending Engineer, South-east Provinces,—(No. 412, Cuttack, dated 20th April, 1850.)

Sir,

I have the honor to forward the undermentioned estimates Nos. 22 and 23, dated this day, for annual repairs of embankments and

inspection bungalows (Balasore), Cuttack division, for the year 1849-50, amounting to Co.'s Rs. 2,032-3-9½.

2. Beyond a comparatively small sum that can be included under the head of annual repairs, no further outlay for earthwork will be necessary for this year. In order to save much time therefore I have accordingly thus submitted the estimate; but I beg permission to add that delay has not been productive of any disadvantage in the interests of Government.

3. In reference, however, to this northern division, I may here forward the annexed memorandum relative to fictitious or useless bunds about which no matter of doubt can exist.

Relative to this matter I shall be able to forward to you more details hereafter, but I think it as well to make you now acquainted with this general summary.

Memo. of Fictitious or Useless Bunds, submitted by CAPTAIN N. C. McLEOD, Officiating Ex-Engineer, Cuttack Division, with his letter (No. 412, dated 20th April, 1850.)

Name of Chukla.	Supposed or present Mileage.	Miles, fictitious or useless.	Miles remaining.	REMARKS.
Ultee, ...	13⅝	7½	6⅛	
Utteecone, ...	41	23	18	
Tishneah, ...	19½	12	7½	
Barrah, ...	27½	15¾	11¾	
Jyepore, ...	0	0	0	Not sufficiently known yet, see Report of Superintending Engineer on the supposed sea bund.
Bhuddruck, ...	26¼	25	1¼	
Balasore, ...	12¼	7¼	5	
Bustah, ...	8⅛	4⅛	4	
Total,...	148¼	94⅝	53⅝	

CAPTAIN ABBOTT, with his No. 159, of 26th August, 1850, sent the following statement.

Statement of useless Banks or Bunds brought within present Mileage of the Embankment, Northern, Central and Southern Division of Cuttack Division.

Name of Chuckla.	Supposed Mileage.	Fictitious or useless miles of Embankments.	Miles to remain in List.	REMARKS.
Central.				
Buckrabad,	38 4 548	25 6 200	12 6 340	
Deagaun,	63 2 180	44 6 530	18 3 110	
Baloobissee,	79 5 510	34 7 490	44 6 20	
Benahar,	75 1 447	45 2 20	29 7 427	
Asseressur,	51 0 0	30 2 550	20 5 110	
Puddunpore,	22 0 375	16 4 5	5 4 370	
	329 7 72	197 5 475	132 1 257	
Southern.				
Serain,	272 7 300	127 1 68	145 6 632	
Rahang,	56 4 10	31 3 0	25 3 10	
Puchum Dobye,	54 0 200	22 0 200	32 0 0	
Lymbye,	63 0 30	30 0 0	33 0 30	
Koordess,	50 1 60	28 4 0	21 5 60	
	272 7 300	127 1 68	145 6 632	
Northern.				
Ooticone,	41 0 0	23 0 48	18 0 0	
Jehajpore,	23 1 235	18 5 220	4 4 15	
Barsah,	27 4 44	16 2 0	11 2 44	
Tifaneah,	19 5 99	12 1 99	7 4 0	
Bhuddruck,	26 2 0	25 0 0	1 2 0	
Balasore,	12 3 16	7 3 16	5 0 0	
Bustah,	8 1 58	4 1 58	4 0 0	
Ultee,	13 5 118	7 4 118	6 1 0	
	171 5 619	114 0 569	57 5 59	

MEMO.

Chuckla Rahang supposed Mileage 65-4-10 and not 56-4-10, difference 9 miles; therefore for that Chuckla 40-3-0 and the total will be, ... 783 4 331

And total fictitious, ... 344 4 548

Total amount of present or supposed Mileage, ...	774	4	331
Do. of useless or fictitious Bunds, ...	438	7	443
Remaining, ...	335	4	548

Those written as remaining will, as opportunities offer, require further testing.

C.

From CAPTAIN J. P. BEADLE, Superintendent of Embankments, Lower Provinces, to the Chief Engineer, Lower Provinces.

SIR,

I HAVE the honor to submit for record Lieut. Short's No. 53 of the 4th January, 1856, with accompanying statement.

Lieut. Short has accomplished an arduous task in placing the Cuttack Office in order: he has brought together, and strengthened an establishment that had been distracted by constant changes of officers, and an absence of confidence and of method on their part in directing the working of the division; he has conciliated the Zemindars and their agents, and won the good-will and co-operation of all in the division from the Civil Officers of Government to the lowest grade of official, with one exception. Lieut. Harris thus enters upon his duties favorably. Office arrears closed, no complaints to be enquired into, and everybody prepared to assist the department, and the information given him by Lieut. Short (who took the greatest pains to make him acquainted with all the details of the division) will prevent his having to serve any long apprenticeship of experience, and enables him at once to commence upon work.

I trust you will recognize Lieut. Short's good working of the Cuttack division and office. He did all that one man could do; and it will be satisfactory to him to learn that his hard work and good spirit have won for him the commendations of the head of his department and of Government.

I earnestly request of you to relieve Lieut. Harris of the roads and buildings without any delay. The separation is as necessary for the well doing of the above works, as it is for the sake of embankments.

D.

Extract from a letter from CAPTAIN J. P. BEADLE, Superintendent of Embankments, &c., to LIEUT. C. HARRIS,—(dated 13th December, 1854).

WE took 3 sections of the Dhya river bed in this low track, and as the salt tides reach up to Keenness and the bed is very contracted, it is quite clear that the Katjooree floods which are passed off by means of the Kokhai branch cannot possibly be passed off by the Dhya exit into the Chilka Lake; and as the Bargovee, falls into the Dhya, and also the Noon, which carries off a great portion of the drainage of the Pooree district, the floods must escape somewhere, and it is this necessity which produced Lieut. Short's project for making a cut from the time of the Bargovee to the Gus lake.

We examined the project, as far as an examination could be carried out without levels, and the result was very satisfactory. On a rough calculation, I made out that the cut would cost from 20 to 25,000 Rs. to complete it with bunds, and that the effect on the Gus lake would be to raise its level perhaps two feet; but this calculation was very rough, and no allowance was made for the water that now finds its way into the lake from the floods of the Bargovee, breaking, pouring over its bunds. I do not consider from a primâ facie view of the project that the station of Pooree would be in the least way endangered, and I understand that the Zemindars think very favorably of the plan and are disposed to assist in its execution. It remains for Mr. Rayner to take the necessary levels.

G.

From CAPTAIN W. D. SHORT, the Officiating Superintendent of Embankments, to Mr. Assistant Supervisor J. MCMILLAN, in charge Central Cuttack Division,—(dated Cuttack, 17th June, 1857.)

SIR,

I HAVE the honor to request you will take immediate measures to remove as much as possible the natural stone spurs situated along the left bank of the Mahanuddy river above and below Naraj, and boat the material to the point where Lieut. Harris, commenced to

Below Naraj at right bank of Katjooree river.

stack* it, and continue the spur as far as possible, agreeably to the instructions which Lieut. Harris has been requested to give you. This is a most important measure, and I beg you will give your best energies to its execution.

K.

Abstract Statement shewing what number of breaches occurred, were closed in, left open, and recurred in the Central and Southern Divisions of Cuttack Embankments during the seasons of 1854-55, 1855-56, *and* 1856-57.

Name of the Division.	1854-55.				1855-56.				1856-57.			
	Total number of breaches occurred during the season.	What number of ditto were closed in during the season.	How many breaches were left open during the season.	How many of the filled-up breaches were re-opened by the floods of 1855-56.	Total number of breaches occurred during the season 1855-56.	What number of ditto were closed in during the season.	How many breaches were left open during the season.	How many of the filled-up breaches were re-opened by the floods of 1856-57.	Total number of breaches occurred during the season 1856-57.	What number of ditto were closed in during the season.	How many breaches were left open during do.	How many of the filled-up breaches were re-opened by the floods of 1857-58.
Central Cuttack.	474	445	29	78	807	714	92	127	366	280	86	
Pooree.	626	610	16	300	553	547	6	215	180	91	89	
Total,...	1100	1055	45	378	1360	1261	98	342	546	371	175	

(Sd.) W. D. SHORT, CAPTAIN,
Offg. Supdt. of Embankments, Lower Provinces.

This is a very valuable document tending to prove the point urged by me, viz., that unless the flood at the head of the Delta be controlled,

the volume passing to south must increase, and that the channels are unequal to give it vent and the embankments must be proportionally breached and the country desolated. In the central division where the flood, although great, has ample water-way, there were in one season 78 breaches closed and re-opened and with those left open (29) a total 107, or nearly ¼ of the money thrown away, and in the next season 129 × 92 = 319 left open and re-opened out of 807.

Again, and more particularly in the southern division in one season one half the breaches closed were re-opened, that is 300 out of 626, and in the next season 215 out of 553. Such a state of things is simply throwing away money to no good purpose.

(Sd.) W. D. SHORT, CAPTAIN,
Officiating Superintendent of Embankments, Lower Provinces.

S.

Memorandum submitted by CAPTAIN W. D. SHORT, Officiating Superintendent of Embankments (and late Officiating Executive Engineer, Cuttack Division), pointing out the causes of the evils existing in the Cuttack Province, and suggesting remedies.

THE Mahanuddy river rises in the province of Nagpore, and flowing in a direction from West to East about 100 miles, turns suddenly to the North for about 100 miles, when running to the north-east about 150 miles, and passing the town of Sumblepore, it flows eastwards, a distance of about 200 miles, to the head of the Delta, in the province of Orissa, and thence eastwards for a further distance of 68 miles, falling into the sea in the vicinity of the False Point Light House, its total length therefore may be estimated at about 600 miles.

2. No detailed knowledge of the river above the Delta was recorded prior to Lieut. Harris's survey and levels undertaken in 1855 and 1856, which commenced at Bydessur (28 miles above the head of the Mahanuddy Delta), where the river for 34 miles has had a width of 2 miles, which continues to 12 miles below it, when it narrows between the Rowtrapore and Domparrah hills, below which it expands to a greater width;

Vide Lieut. Harris, Plate 1.

and lastly, before entering the low flat lands, contracts to less than half a mile within the rocky neck or gorge, (formed on the right bank by the Sydessur and Naraj hills, and on the left, by the Domparrah hill, and the rocky boundary below it), then, immediately below the Naraj hill, the pent-up volume is shot out over the waste of sands at the head of the Delta.

3. The neck of the river from Sydessur hill to Naraj is about half a mile in length and less than half a mile in breadth, and rock-bound; it is only therefore from *below* Naraj hill (where the volume debouches into the plains and the Katjooree river is thrown off) to the coast, a distance of 68 miles, that it becomes a question for consideration, how the water can be controlled to benefit central and southern Cuttack by means of irrigation.

4. Above, where the river is confined within rocky boundaries, the section of the bed represents a series of basins, within which the flood is, it were, heaped up, because arrested below by the narrow rocky neck wherein the velocity may be said to be initial, but immediately below Naraj, the velocity for the first 6 miles in the Katjooree, 9 miles in the Mahanuddy, as also the fall in the bed, is greater than from these points to the sea, and as the depth of water, velocity of current, slope of bed, and tendency of the volume to fall to the south and south-east is the greatest at the head of the Mahanuddy Delta, the directing and controlling power should evidently be applied at this point.

5. Up to a recent date, that is to about 1840, (vide the revenue survey maps,) the direction taken by the greater portion of the volume was down the main channel, that of the Mahanuddy, and the country was embanked by the landowners according to necessity, or the fluctuations in the levels of the high banks, which were from time to time eroded by changes in the set of the currents, as described in the subjoined report. Thus, it is only since 1840 (owing to the removal of the high ridges of sand, at the head of the Katjooree river, and the consequent fall down the river) that the water-way of the Mahanuddy has been steadily decreasing, and the rise in its bed (owing to the decrease of scouring action) proportionally increasing, until in 1857 I found the climax had been reached, the bed of the great Mahanuddy having so silted up, as to have become, for the first time on record, dry (with not even a low water current), whilst

the head of the Katjooree took in the whole of the low water current (which flows from January to June), and its bed so scoured by the increased volume of flood, that the level of the low water, at the head of the Delta, was two feet below that of all former periods, which accounts, in a great measure, for the absence of all water in the Mahanuddy channel.

6. The nature and efficiency of the protective measures carried out up to 1840 and from that period up to 1856, have been detailed in a separate report, and in proportion to the ignorance, procrastination and diversity of opinion on the subject, the evil increased and when it is considered (vide annexed report) that during a period of 9 years, remissions of revenue to the great amount of 23½ lakhs of rupees were granted, and that from 1848 to 1856 the inundations increased yearly (calling for continuous remissions), it is a source of wonder that the Government did not discover through its officers, the root of the evil, and thereon invest capital to counteract it, whereby a good and certain return for the outlay, not to mention the permanent benefit of the community and the prosperity of the province, would have resulted.

7. There were no native works (excepting a few sluices) in existence, to point out that at a date prior to our occupation, any value had been attached to the great volume of water rolling uselessly to the sea, and nothing *permanent* has been *since* attempted to turn the advantages to the benefit of either the Government or the people. Heavy as the expenditure has been in the aggregate (vide annexed table), no permanent good has been effected, every remedial measure or scheme of improvement, having been invariably adopted at points where the *effect* has been patent, rather than against the *cause* of the evil (which was yearly increasing); for instance, the town of Cuttack had been threatened with destruction for many years, owing to the known insecurity of every part of a revetment founded upon sand, and ever liable to be undermined and breached, with the level of the highest flood 6 feet above that of the town, (and 7 feet in 1855-56) when, to counteract this, various schemes have been, from time to time projected, viz., breaking banks of stone, &c., &c., and finally Mr. Simms, the Civil Engineer projected (I believe) the future permanent safety of the town and revetment (which were not worth such an outlay) by the construction of a well founded work, at a proposed outlay of some 18

lakhs. Every view appears to have been limited to the *protection of the town and cantonments*, which are not, either from their position or intrinsic value, worthy of consideration, when compared with the permanent *interests of a great province*; thus, one object to be reported upon yearly has apparently cramped the character of all measures, whereas had more enlarged views, when entertained, been laid before the Government for their favorable consideration (vide my report of January 1855), I believe the result would have been an order,—

Docket E.

1st. To abandon Cuttack as a station, and occupy a new, and in every way, a better, site for it, on the crest of the rocky plateau on the opposite or left bank of the Mahanuddy river.

2ndly. To compensate the house-holders not only for the certain loss of their houses, but enable them to rebuild these in a regular form near the new cantonment, which ought to be built, more as a strong Military post, having a command over the town and the approaches (the natural features and the stock of material being well adapted for such measures).

3rdly. The public offices constructed in the centre of the new Military post, and double-storied, the lower portion for records (which in our department are invariably allowed to be lost or eaten up), the upper for the offices of the several departments.

4thly. Excavations of great tanks on the rocky slope of the hill (below the new cantonment), which could be yearly cleared and refilled by the floods, for the health and benefit of all parties.

5thly. The construction of a very heavy embankment below the town and Civil lines, connecting the right bank of the Mahanuddy and the left bank of the Katjooree, to protect the lower part of the island at top of which Cuttack is now situated.

Vide Plan.

6thly. The abandonment of the town and cantonments, and the *removal* of the whole of the stone in fort Barabutty and revetment, (by tramways over the sand) to form (in one or two seasons) at the *head of the Mahanuddy Delta, a great and permanent dam or weir, to control (for the future) the floods, divert the main volume and make it run into and scour out the Mahanuddy, render that river navigable, control the volume to the south and south-east,* (which now causes desolation) and develop a system of irrigation. No sooner would the

chief measure be carried out (viz., the stone dam or weir at head of Delta) and its effect seen, than opportunities would be afforded to study practically the conditions of the several rivers or escapes, and year by year the Government would obtain satisfactory results by an increase of revenue, (the present settlement I believe having nearly lapsed;) cessation of remissions which are now the rule, and increased prosperity to a great district with means of water-communication to the coast, whence the produce of this fertile Delta might be made available for the relief of less favoured tracts. I am of opinion that nothing less than the acceptation of the means proposed by me, will afford the Government any *permanent* good, whilst there is nothing but protracted anxiety, with the probability of the occurrence of some sudden and terrible catastrophe, by indulging in further procrastination, and throwing money away in endeavouring hopelessly to save the revetment and town, and stem the Katjooree flood, whilst the root of the evil is not attacked and overcome. I would now record what I conceive the causes of the many evils which have tended yearly to deteriorate the security and prosperity of the central and southern province of Orissa, and to suggest the remedies.

Remarks and Remedy proposed.

There can be no question regarding the ignorance of all parties up to December 1854, as to the necessity of controlling the volume of water at the head of the Delta, for *no individual* had ever suggested *aught* to invite attention to this, the *main point*, but all had, as proved by the works undertaken and the special committee (headed by Mr. Simms, C. E. convened at Cuttack to provide for the efficient safety of the revetment and the town), adopted measures, and *made suggestions against the symptoms produced,* without touching upon the *root of the evil.* In 1854 the increase in the volume and velocity of the flood down the Katjooree river, and the consequent terrible visitation to the province led me, (as officiating executive Engineer) to interest myself deeply on the subject, when, from examination of the head of the Delta and comparing the *then* state of deposit with that (portrayed by the revenue survey maps)

Cause.

1. Ignorance up to December 1854, of the root of the evil, viz. the *non-controlling of the volume of water at the head of the Delta;* and from January 1855, vide docket E. inattention to the remedial measures proposed, and continued procrastination up to July 1857, in not arriving at final decision on such a momentous subject.

in 1840, I became convinced, and reported specially (vide annexed copy) in February 1855, that all measures, of whatever nature, carried out where the symptoms were, would be abortive and that unless effective measures were immediately taken to *control the flood at the head of the Delta*, to divert the volume into the Mahanuddy river (its main channel, and so fully equal to receive and discharge it), and thereby lessen the excess volume poured down the Katjooree channel, the inevitable result would be the destruction by inundation of Cuttack, the desolation of the south-eastern portion of the district, and more particularly of the southern or Pooree division, and last, though not least, the silting up of the bed of the main stream (the Mahanuddy). Thus, in January, 1855, I recorded my views, and thereon *claim the originality of discovering the root of the evil, and conceiving the plan of controlling the waters of the great Mahanuddy*, and although the work proposed to be executed, viz. a *flêche of masonry* may not be the most effective means, ignorance of the nature or detail of works constructed at Madras for a similar purpose, led me at *that* time to propose a measure, which appeared to me to have the double advantage of giving a limited *rock-bound* escape for the Katjooree (and thereby, water for the population at Cuttack from November to July,) and also confining the Mahanuddy at a point, where the volume takes, as it were, its first spring into the Delta, whence the current would, for the first mile or two, take its direct and proper pathway. The fall of the torrent over the masonry weir would distribute the volume and lessen the velocity toward the south and south-east, whereby the revetment, town and district would be preserved from a volume of water, which cannot, under existing circumstances, (particularly when met by spring-tides and adverse monsoon) be passed out through the natural vents, without a continuous breaching of embankments. I am inclined to adhere to my original proposal, viz. to construct the dam or weir in the form of a flêche, and leave a clear vent at the head of the Katjooree (between the rocky boundary Naraj and the work to be carried out opposite to it founded upon wells), whereby an efficient scour would be given down the *then* limited head of the Katjooree, and a deep clear channel maintained for navigation, &c. The weir (founded upon wells) to be commenced opposite to, and at a distance of about 500 feet from Naraj; and to extend with a

Docket E.

curve (nearly parallel to the left bank of Mahanuddy) to the Temple Island, whereby the flood would be retained within the Mahanuddy channel, and scour out its bed (which is well able to contain it) as also those of its several escapes. Should this not be considered the best project, then it remains only to have a continuous weir or dam from Naraj to the Temple Island, the details of the work in either case will be founded upon the experience of similar works in the Madras Presidency, from whence the information may be procured.

Vide Plan.

Vide Plan.

Conceiving that there is not a doubt but that the Government will order the execution of the only measure likely to be of any *practical benefit to the district,* and considering that *time is money,* and that the *evil is yearly increasing by procrastination,* the means of carrying out so extensive a work must be examined into. With abundance of stone at the site, with good hydraulic lime, labour cheap and, if well remunerated, available to a very large amount, it appears that energy alone is required to give the Government a return for the outlay and security to the district.

The quarrying of the required quantity of stone, and placing it in position would occupy, I conceive, five or six seasons, during which the evil must increase, viz., the *lowering of the Katjooree bed,* to the detriment *of the main stream,* to re-open which, the difficulty will be increased an hundred-fold.

The earliest and most practical measure to meet the evil and provide the remedy, is to abandon the revetment, the town, and Civil and Military buildings and to select a new, and in every way excellent site, on the rocky plateau on the left bank of the Mahanuddy, opposite to the present cantonment, the stone of the revetment and fort is ready cut, and would provide in one or two seasons the material for the weir, and could be conveyed readily to the site over tramways. Compensation to be given to the towns-people for the probable loss of property, with a trifle in excess to enable them to rebuild on the opposite bank, and the new station to be constructed more as a Military post, with the public Offices concentrated therein.

The lower part of the island (at head of which Cuttack is situated) to be protected by a substantial embankment (a mile below the town), when the waters would spread over the head of the island, raise the level and lose their influence for evil.

When a practical knowledge, from careful personal survey (which the inspection of a mere plan does not sufficiently convey), has been obtained of the vast field of deposit at the head of the Mahánuddy Delta, and it be considered that the flood, *before it rises in excess*, glides over without disturbing the deposits, the influence on their height, and position, in deflecting the current, is of considerable importance; and if the existence of an ordinary deposit in the bed of a river, (in causing a set against the bank,) be injurious, how proportionally important must be that of the sand hills at the head of the Delta.

2. Inattention to the changes yearly occurring in the formation and position of the great deposits at the head of the Mahanuddy Delta.

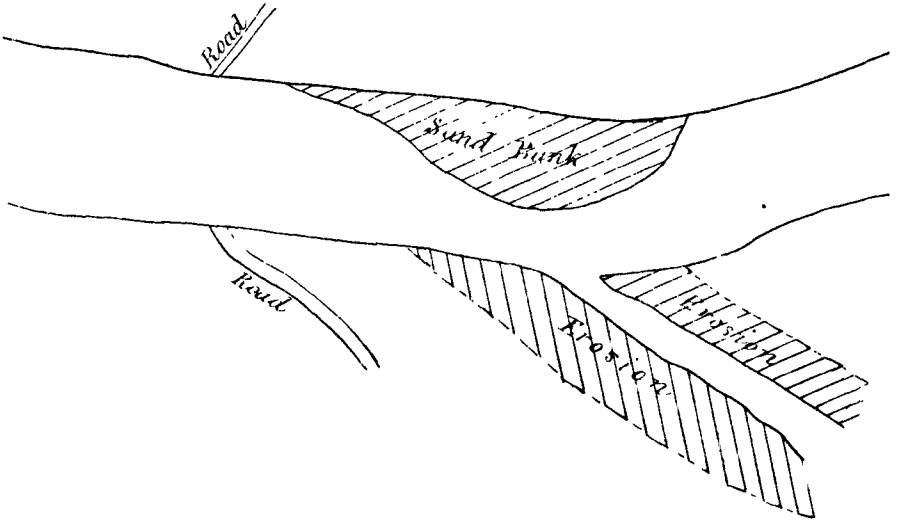
Prior to 1840, the revenue survey map shews the position of sand-bank acting as a great spur to deflect the current away from the head of the Katjooree into the Mahanuddy river, and in proportion as this was eaten into, the head of the Katjooree enlarged, till finally it receives the whole of the low water current. Simple, economical, practical, and timely measures, which tend to influence a current at its *outset*, are neglected, and when the evil has occurred the opportunities for effecting good are lost.

Vide Plan.

1. The Byturnee, a large river, the boundary between northern and central Cuttack, had a fine well-scoured channel, and immediately below (half a mile) the point where the Juggernauth road crosses, there was small unembanked escape falling into the Kursooah river, a deposit of sand formed just below the ghaut,

3. Inattention to the position of deposits at the head of the several rivers or escapes falling out of the Mahanuddy and other rivers, whereby the volume of water is retarded, or deflected and unequally disturbed.

There can be no two opinions on this point amongst practical men, suffice it that I will adduce the evils that have resulted from either ignorance or inattention to this point.



and increasing, deflected the current against right bank, and after a series of years, the escape has more than doubled in section, conveying to the Kursooah an excess of flood, which that river (already over-fed by the Brahmaney) cannot contain. This causes enormous breaches in the Kursooah, destruction to the lands by sand deposits, and a proportionate silting up the main stream (the Byturnee) whereas had 200 rupees been timely expended in cutting through and removing the deposit (which ought now to be carried out) large tracts would have benefited.

2. Again the Kursooah channel has been scoured by excess flood from the Brahmaney, the country has been yearly more and more devastated, simply because a great sandbank near the head of the Kursooah has been allowed to deflect the current from the main channel; moreover a former petty channel from the left bank of the Mahanuddy (falling into the Kursooah just above the ghat) has doubled in section within a few years, to the manifest injury of the Brahmaney channel, whereas, measures should be instantly taken to dam up this escape effectually and permanently, cut away the great deposit in Brahmaney, (near head of Kursooah) construct a bold spur at head of Kursooah (left bank) to deflect flood into Brahmaney, when that channel would be scoured, and I believe, with a weir judiciously placed, for which material in abundance is available, it might be rendered navigable for light boats.

This is a very important point, and an outline survey should be made at once with a view of orders being given and timely sanctioned.

Again a short distance below the passage of the Brahmaney river on right bank, the Kenerwah nullah runs, and falls into the Beropah; now this channel, from an escape, has become a river, conveying away an excess volume from the Brahmaney, whereby the fine deep channel of the latter is deteriorated by silting up. I strongly recommend a weir across the head of the Kenerwah to throw back the water into the Brahmaney, and at the same time regulate the flood down its own channel; which, with the measure,* would make the Brahmaney a fine channel.

* Par. No. 2.

3. Again below the salt golahs, the Brahmaney throws off the Chota Brahmaney, originally a petty escape or canal, embanked throughout.

A very extensive sandbank in the Bara Brahmaney below the head of the escape, by impeding the current has caused the head

of the Chota Brahmaney to widen, whereby excess flood yearly rushes, breaching the embankments enormously, and swamping a fine and extensively cultivated tract.

This could and ought to be readily prevented. Remove the obstruction and regulate the head of the escape by spurs, when extensive estates will be fertilised, instead of being ruined. This could be done at once.

4. Again the Gungaotee nullah is an escape from the left bank of the Beropah, and is intended to carry off the drainage of an extensive tract west of the Juggernauth road. The drainage from the range of hills tends to scour its channel, in addition to which an excess volume is poured into it from the Beropah by reason of inattention to the state of deposit in the bed of the Beropah, near the head of Gungaotee. The excess flood, whilst it scours the Gungaotee, inundates in excess the open country on either bank, and deteriorates the channel of the Beropah by lessening the scour.

5. Again the head of the Bara Chukertollah river has been unattended to, and the bed has silted up considerably. It has a fine capacious channel with high banks, and, in my opinion, means should be adopted to deflect a greater body of the Mahanuddy flood therein, when this river, with its continuation the Noon (which has a fine, deep and very direct channel, with the tides serving well up it) would be the most direct and favourable channel of communication between Cuttack and the coast at False Point, whilst the measures already advocated by me to regulate the head of the Kursooah, close its second channel, and throw the greater body of water into the Brahmaney (and also regulate the Kamereeah channel) would make the Brahmaney a *second* channel of communication to the coast at Dhamra.

6. Again the head of the Chota Chukertollah (in all seasons of heavy flood) receives an excess volume of flood, which its originally narrow tortuous channel cannot pass off; hence the embankments at the bends of the stream are heavily breached, the country inundated, and the crops destroyed. Means should be at once taken to regulate the channel at head, and deflect the volume more into the Noon river.

7. Again the narrow tortuous channel of the Sookhpykha, running out of the right bank of the Mahanuddy, has been unattended to, the consequence of which has been increased volume of flood,

which has breached the embankments at the angles, and injured the villages and cultivation.

8. Again the head of the last escape from the right bank of the Mahanuddy, the *Pankpaul* river, has, owing to a large deposit in the main stream deflecting the current, so increased, that the Pankpaul receives an excess volume which breaches (enormously) the originally fine line of embankment carried out by Captain Rigby, and inundates the extensively cultivated tract to the south. This evil might and ought to be readily remedied by simple measures at the head of the channel.

9. Again, about 3 miles below Cuttack, the Katjooree river throws off the Soorooah, the right bank of which is embanked throughout. Now, this was originally a small escape, but owing to the natural fall in that direction, and inattention to the head of the channel, a greater volume of water has, for years, passed down it, scouring it to a very great degree, and as the vent is unequal to pass off more than, I believe, one half of the volume poured into it, the consequences have been, of late years, terribly disastrous; the heavy embankments swept away in one instance 1300 feet continuously, the flood sweeping to the south and carrying devastation with it. Whilst this has been going on, the main large channel of the Katjooree, with its high banks, has silted up proportionally, especially near the head of the Soorooah.

Now immediate measures should be taken to remove the sand, and cut a channel at a lower level than that in the Soorooah, and deflect the current therein by heavy spurs from the right bank of Katjooree above head of the Soorooah. This, indeed, is a most important and urgent point, and the Katjooree should be made to carry off its proper volume, when the country to the south of the Soorooah will be preserved.

10. Again the Katjooree river (below the mouth of the Soorooah) after throwing off its excess flood down the many channels along its right bank, rejoins the Mahanuddy (vide plan*) with a considerable body of water, at a point where the last escape (the Olouka Nuddee) leaves it, the greatest variation has been allowed to take place, viz., the head of the Olouka has yearly increased, and this channel (embanked throughout, and formerly intended as a canal for irrigation), has so enlarged as to receive by one half a greater body of water than it can give vent

* Revenue Survey.

to; consequently the embankments are fearfully breached and the country desolated, and at the same time the Katjooree channel has deteriorated proportionally. This state of things should be at once remedied by reopening the Katjooree channel and controlling the head of the Olouka, or the evil will, ere long, be irremediable, except at a very heavy outlay.

11. Again with a similar view the head of the Bilookhye Nuddee (situated above that of the Olouka Nuddee) should be controlled, as at present an excess volume passes down its channel to the detriment of the embankments and the country, and deterioration of the Katjooree channel, and, at the same time, the dam at the head of the Jumpooa Nuddee should be efficiently looked after and secured.

12. Sufficient importance has not been attached to the head of the Daib river which runs out of the right bank of the Katjooree below the Soorooah river. This is a very fine deep river, tidal up to and above Daibdale, and very good sized vessels have, of late years, entered the river from the Madras and Bombay presidencies to transport the rice of the district. A very little attention to and expenditure at the head of the Doel and below to Daibdale, would enable large boats to come up within a short distance of Cuttack.

13. Again, in the southern division, a weir might be judiciously placed across the head of the Kokai river, to regulate the flood to the south; indeed this would be of incalculable benefit, for if the measures proposed to control the Katjooree at its head be not *speedily* executed, a sudden erosion of the stiff projecting right bank at Chargurreah would lead the flood to make for the south (as it now does yearly in excess), when the embankments would not only be breached enormously, but the southern division would become an extensive jheel.

14. Again, the head of the Kushudra river, formerly a fine escape from the left bank of the Kokai, has silted up very considerably, and measures should at once be carried out to remove the deposit, and deepen the head of the channel to a level with the bed of the Kokai, when this fine escape would carry off its proper quota of flood, and ease the Bargovee and Dyah channels. Indeed a weir might with great advantage be given across the head of the Kushudra river. Stone could be obtained from Bhobanessur and the outlay would be readily returned by the increased prosperity of the country

(along either bank of the river) and the safety of the embankments on the Bargovee and Dyah rivers.

15. Again, with similar advantage, a weir might be thrown across the Kokai, stone in the vicinity being abundant at Bhobanessur, above the head of the Bargovee and Dyah rivers, whereby these channels could be regularly adjusted, at a point where at present the greatest variation occurs, to the detriment of either one or the other of these channels and their embankments.

16. Again the head and channel of the Kouchee nullah, which falls out of left bank of the Bargovee, a little above the road ghaut, has been neglected. Its importance has not been sufficiently recognised, and measures should be *at once* adopted, on a *large scale*, to clear, open, and enlarge the head, improve the channel, remove deposits, strengthen the embankments and make this channel a fine efficient escape for the Bargovee floods into the Sur lake, when the lower reaches of the Bargovee will be eased, and the embankments be less tried; moreover, during high flood level and simultaneous spring tide, the waters which are pent up in the Bargovee would pass off into the Sur lake and the enormous breaches on the Bargovee would not occur.

17. Again, the same measures may, with advantage, be carried out during the working season (and flow of low water current) at the heads of all the silted-up escapes leading out of the lower reaches of the Bargovee; whereby, at a trifling yearly expense, much evil and irregularity will be uprooted to the benefit of the district and the relief of the embankments.

4. A system of embanking founded upon erroneous principles, continued and endeavoured to be maintained at a vast expense against all reason and experience.

Embanking (as a system) throughout the Delta must have existed at a very early period, and I would conclude that the individual who conceived and executed such a work as the revetment, may have turned his attention also to benefiting the interior of the district, and if so, protective measures must have existed for 7 or 8 centuries. At such an early period the general features must have been, as far as irrigation was concerned, very different; for the Mahanuddy was *then* the main stream, receiving and carrying off the great volume of flood, and the Beropah, a great river; as exemplified by the revetment, still found at one locality, in every way similar to that on the Katjooree. The banks

of the Mahanuddy were ever high, and even to this day (excepting the lower reaches) the embankments are in isolated lengths, only across dips, proving that the channel was and is fully equal to contain its flood without detriment to the country, whereas the Kokai and Katjooree were, in comparison thereto, small escapes.

However, in proportion to the change effected at the head of the Delta and the increase of flood to the south, arose the necessity (in ignorance) of embanking in excess to the south and south-east. Small irrigating channels became nullahs, and nullahs rivers, and as year after year the increased erosive action from excess flood cut away the banks with their embankments, curves, called dobundees or retired lines, were carried out as seen to this day. This work of ignorance in "attempting to oppose volumes of water by imperfectly constructed earthen embankments" answered, in a measure, at the heads of the channels where the section was large, but in the lower reaches where the section is one-third less, the embankments (originally marginal) have been, as necessity called for it, raised to the extreme, in the vain hope of confining the flood, which has resulted in enormous breaches and proportional throwing away of money in closing them. When it is remembered, that *all* the rivers and escapes in the Delta are *funnel-shaped*, (the section below one-third, and quarter, and half less than that at the head), that the flood *must* find vent, that it is not only impeded by the narrowness of channel, but by powerful spring tides driven up by a strong monsoon; and that, as the volume of water rises over the banks to ease itself laterally, heavy embankments impede it, it cannot be wondered at, that the pent-up volume, checked below and laterally, forces its way through the weakest part of an earthen embankment.

We *found* embankments, and continued to *raise* them, because it appeared more economical to do so, than to construct new lines, forgetting that they were raised under a wholly different state of things, and we ignored the necessity of a change of system to meet the altered circumstances; whereas, instead of increasing the embankment sections, the marginal lines should have been abandoned, and new *well* retired lines carried out, more particularly along the lower half of the river. The ignorance and inexpediency of past measures is now made known, the means to regenerate the province are patent, viz., to "control the floods at the head of the Delta," and thus obtain a

complete command over the main volume, then to carry out judiciously a system of embankments (of the benefit of which there can be no doubt in all practical minds) strong and aligned, and sufficiently retired to leave a free passage for the highest flood without impeding its velocity, and thereby preventing, in a great measure, the erosion of bank and formation of curves, that every means be employed to improve the curves in the escapes themselves, and instead of having, to the south, but one contracted channel falling into the Chilka lake, to cut a *second* from the Sur lake to the sea (as proposed by me in 1855), to ease off the pent-up floods of the Bargovee rivers.

This evil is but too well known. What an amount of correspondence has passed relative to the saving of the revetment and Cuttack? how many measures have been proposed? and lastly, a Committee was presided over by an eminent Civil Engineer, Mr. Simms, and what has been the result? the estimate was, I believe, 18 lakhs, to save a revetment and town, &c., that was not worth one-fifth of the amount, whilst the protection of the well paying district has been a *secondary* consideration. All the papers and plans were simply removed from the Board's Office to the Chief Engineer's, and eight to ten years have passed without a decided opinion being given on the measures proposed.

5. A system of conducting business by means of voluminous correspondence, whereby the benefit that might be given to the district and Government, from the local knowledge, and power for good of the executive Engineer is nullified; and projects remain under consideration for years, when if they are not approved of, nothing better is ever suggested by those whose more mature judgment ought to settle the question.

It is however fortunate that the proposed remedy was not attempted, for the money would have been, I believe, thrown away.

In January 1855 I projected, what I still maintain to be the only practical remedy, and allowing that more experienced men might improve on the measures proposed, there is no doubt that whatever the precise shape the weir *might* be eventually, it was an imperative duty to order the quarrying and collection of a vast quantity of stone, whereas two and a half years have passed, and we are as far from the accomplishment of the *one thing* needful, as ever.

This system was carried out till May 1855, since which, the one charge has been converted into six. Six executive officers were appointed to spend money, viz., three embankment divisions, one road division, one build-

6. A system which (till lately) placed embankments, roads and buildings (extending over a province, the area of which is but a little less than Wales) under one executive Engineer,

without assistants, surveyors, levellers, and overseers, but with a subordinate and very inefficient establishment of men call darogahs whose salary varied from 5 to 10 rupees a month.

ing and road division, and one Chief executive on the embankment department, to survey and report upon the rivers of the province. The breaches have been, of late, so numerous, that with extreme difficulty they have been closed before the arrival of the next year's flood, and great sums of money are spent in the Pooree division in raising and strengthening embankments, which, when the flood at head of Delta is controlled, will be unnecessary and which, without that measure, will be invariably breached at one point or other.

It is not the number of officers, but working at the proper point, that is required, and until this is settled, the evils will increase. The inefficiency of the working establishments all parties are agreed upon, the darogahs are grossly illiterate and fraudulent, they are harpies who prey upon breaches, all the money made has been obtained by closing the *same* breaches year after year, and yet no improvement takes place; salaries were to have been increased from 1st November, 1856, to obtain a better class and the 1st November, 1857, is at hand, hope is deferred, and temptation (owing to increased expenditure) is increased a hundredfold.

This point has been clearly shewn in detail in the annexed report, suffice it, that not only was breach of faith committed, but, as no final decision was arrived at, the embankments steadily deteriorated, until the crisis of 1855, when the rivers, in full volume, poured through 1365 breaches, aggregating 25 miles in length. Embankments are doubtless useless as long as the volume of water passing between them is double to what the channel can pass off, but if the water is regulated, the strong embankment affords protection, also a land route, without contracting the water-way, and if sluices for irrigation and drainage are given, the system must be beneficial. The difficulty lies in the Government not having hitherto got at the root of the evil, (which I pointed out in January 1855,) competent Engineers not having provided remedies founded upon practical experience, and extreme opinions being entertained on the subject, from which latter cause the Government have suffered considerably. One individual is for the abandonment of

7. Indecision on the part of the authorities as to whether the embankments should be maintained or not, when their non-retention was a breach of faith with the landowners, and meanwhile the district has been brought to the lowest scale of insecurity and desolation.

the embanking system, the consequence of which would be the formation of vast jheels in the interior, teeming with malaria: whilst others recommend controlling excess flood within huge *earthen walls*. Simple measures and moderate opinions, as they do not produce elaborate plans, reports and heavy estimates, do not meet with due consideration, whereas in Holland, repairing *rat holes* is of the greatest moment.

By means of friendly intercourse with Zemindars and other means, the system was made known to me and tracked out, numerous cases were discovered and the parties tried and convicted; in one instance a heavy breach had been closed apparently very well and turfed over, when on examination, the interior was a *shell*, or made up of strong jhantees and brushwood. In most cases discovery was hopeless, unless the *secret* was possessed, for at the *very* locality the embankment was well sectioned and turfed, giving no grounds for suspicion; in addition to which, the necessity of obtaining water has led to an organised system of cuts in the embankments, which it is impossible to prevent, and these are all entered as "breaches," by the darogahs, who are regularly paid by the landowners for permitting them. Indeed, it is not to be supposed that people so dependent upon the land for their living will stand upon any ceremony in obtaining a portion of the *running stream*. When the crops are being dried up for the want of water they prefer bribing the darogahs, and indeed, rather than not get the water by cuts, they will go to jail. Unfortunately, however for the landowners, the cut that has been opened to receive a moderate flood, is rendered an extensive breach by the sudden and unexpected increase of the volume of water, which inundates and destroys the tract of cultivation it was intended to fertilise.

8. Deficiency of sluices for the purposes of irrigation and drainage, in a province most remarkably subjected to drought and inundation; to remedy which, the landowners have had recourse (as described by me in my Journals, and also especially reported upon) to a system of secret nullahs, or covered passages in the embankment; which, in seasons of paucity, of local rain, are opened to admit of passage of flood from river, and in seasons of heavy local flood are sources of weakness and consequent breaches, all of which are duly entered in the list of breaches by flood.

These evils are not to be prevented without sluices, and a well-organised system, which, at present, *does not* prevail.

As long as the ryot has his own fields to look after, his labour cannot be made available on the embankments, this is natural. In the southern division, formerly every in-

9. Low rates allowed to the labourer, which are decreased by the deductions made by a set of low paid defrauding darogahs, whereby labour is not

available to the full extent, because the coolee is better paid by his zemindar (under whom necessity also obliges him to work), and nothing but sheer want induces him to come under the clutches of an embankment darogah; hence in all seasons of heavy local damage, the inability in one season of providing the labour to meet the emergency.

land mouzah or village was made to furnish its quota; but long since this has been a dead letter. When there is a breach, the labour of the villages immediately interested is available, but distant labour is only so, when a zemindar or Deputy Collector is present to ensure attendance.

There must (in justice) be two rates: one for *local*, the other for *distant*, labour; because the latter has to be provided with food. Compulsory labour is to be deprecated, and yet to save a large tract there should be, I am of opinion, *(as in Holland,)* a law to enforce it; but at the same time adequate remuneration should be given, which under the present system could not be expected. The present system is exceedingly vicious. The darogah gains in various ways, 1st by deceiving the labourer, and secondly the Government. As the charges are extensive, every length of work is estimated for by darogah, who gives it over to a friend of his in the village, with a small advance, with which the latter purchases cowrees at a favorable rate, and pays each coolee 2 cowrees for each basket of earth (dekne ka waste), when he makes his own rate of exchange on the most favourable terms for himself; the work is carried out roughly, and finally the section of embankment is completed; and as no one could give the detail, the darogah returns so many cubic feet of work by contract, and so much daily labour for ramming and levelling. The various other means employed to make up for a small salary, need not be here enumerated: suffice it that no remedy is applied.

The Executive comes and goes,—his movements duly reported in advance,—when every thing is made square until his back is turned. If cuts are not closed, and discovered by the Executive, there is always some poor wretch in the village seized, and sent to jail for 6 months, where he is fed and cared for, whilst the zemindar feeds and looks after his family, and the culprit returns, perhaps to do the same next year.

10. Want of friendly or common intercourse between the Engineer Officer and the landowners (whose interests the former has to protect), which has led to the latter ignoring the existence of an executive, and induced them to throw themselves into the arms of the darogah, who is paid for allowing cuts to get water, for reporting them as breaches, for strengthening any weak points opposite the village, and, for allowing the cattle to graze on the turfed slopes.

There are many excellent zemindars who would give a strong

helping hand to the Executive, if he sought for it. The above facts were not only made known to me by zemindars, but were proved by the cases that came under me as Joint Magistrate.

This is too well known to be enlarged upon. The district will not be regenerated, unless respectable and well paid English Accountant or Clerks of the works are appointed, with a suitable office staff. An Engineer cannot give the Government a return for his staff salary as long as he is a Head Clerk, and the evil requires a prompt remedy.

11. An office establishment numerically weak, and otherwise incompetent to control the mass of papers and accounts, thereby compelling the Executive to have his valuable time taken up as a Head Clerk, instead of checking and controlling work and expenditure out of doors.

This is a crying evil, and it is difficult to provide a remedy. However, if a man's experience and ability entitles him to increase of salary, he should (unless in cases of sickness) be allowed to remain at his post, there should always be an Assistant Engineer, and *he* and the *Executive* should go out alternately, thus keeping up a regular check on the mofussil, and when one is ill, the other can do extra work.

12. Frequent changes in officers, whereby one no sooner commences to gain some knowledge of the work and is interested in it, than he is ordered away on one account or another, when the office establishments and the mofussil subordinates have good opportunities of imposing upon the ignorance of the Executive. Moreover these changes cause endless arrears and references, the valuable time of men at the head of the department is taken up to settle a point (which happened 6 to 10 years back) with imperfect data whereon to form a judgment.

I conceive the disadvantages of the old system perpetuated by taking up the valuable time of supervisors and Sub-Engineers in checking voluminous accounts. Their journeys are proportionally rapid, and unsatisfactory, because there is an office to return to and supervise.

13. Appointment of experienced men as Sub-Engineers and supervisors for the purpose of carrying on and checking work, and nullifying the object by making them heads of offices of accounts.

There should be one head office at Cuttack with an efficient clerk of the works and office establishments, and the Sub-Engineers or supervisors should, when not on tour, come and check accounts, &c.

In the first instance the embankments were raised by the excavation of irregular holes and ditches along and close under toe of interior slope, and the excavations on river side were also very near the exterior slope, (as evidenced throughout the division) the consequences have been that

14. Breaches and their causes.

the interior slope, when saturated by rain, and its foundation sapped, has fallen in masses into the holes and ditches, when these so-called slips have entailed in the aggregate 5 times the amount of new lines, also the ditches in front, when close to exterior slope, have similarly influenced the outer slope and caused breaches.

Again, wherever a breach has occurred there is a proportionate deposit of sand, and this sandy foundation has been allowed to remain, and the new embankment raised thereon, when time after time the breach re-opens at the same locality; whereas, had the sandy foundation been in the first instance well cleared out, and the embankment raised on a good substratum, a recurrence of the calamity would not have had to be reported. Indeed in realizing the embankments, there should be as much attention paid to the distance of the excavations from the slope, as to the efficiency of the section.

This I have considered it necessary to point out, because had I never benefited by the experience derived from a detailed knowledge of the province, I should have been unequal to the task of replying as fully as I have, to the calls of Government; indeed with the numerous rivers and escapes, and the great volume of water poured down by the Mahanuddy, no person can fully grapple with the difficulties, unless he has seen them at the worst, and been in a way responsible, and it is equally impossible for the superintendent of the embankments, with 11 divisions under him to give his time (even if he possessed the local information) to the settlement of the very numerous questions; and counteract timely the various evils detailed by me. With the superintendent there should be an assistant, either an engineer officer or a good man from the upper subordinate department.

15. Absence of a permanent local head to the embankment department at Cuttack as superintendent, one whose experience on the subject would give his views solidity and support, and who (*together with an energetic* Commissioner) might, in 3 to 5 years, develop the resources of the Orissa Province, secure water-communication to the coast, provide well aligned irrigation channels, and in every way give the Government and the landowner cause to be satisfied, instead of having yearly to report on the causes of the breaches and their results.

I conceive this measure very desirable, and believe the greatest good would accrue. The tides would serve directly in and out, the channel would enlarge, the scour would deepen it, the rush of the volume of water in the flood season from the head to the mouth would create a fine deep con-

16. Lastly, instead of the present outlet for the Chilka lake, there should be a new cut immediately carried out from the bottom of the lake direct to the coast.

tinuous channel for navigation, and eventually by means of groins, (the material for which is close at hand, having merely to be quarried and boated) this great lake might be a haven for vessels. The object is a great one and, as far as my knowledge of locality and the coast goes, I see no difficulty in carrying it out. A good rate and energy would soon accomplish it.

From CAPTAIN W. D. SHORT, Superintendent of Embankments to CAPTAIN C. B. YOUNG, Officiating Chief Engineer, Lower Provinces,—(No. 1204, Midnapore, dated 28th August, 1857.)

SIR,

IN reply to your No. 2888 of the 15th instant, I have the honor to submit the information called for on the several points detailed in your letter.

Nature of orders in force in Cuttack division.

1. I would refer you to 7th para. of my report, wherein I have shewn that, owing to Military Board's letter No. 3181 of 1st March, 1847, the embankments (consisting as they do of perishable matter, and subject to action of strong monsoons, heavy rains, extraordinary floods, not to mention the slopes being during the year, and particularly in rainy season, the pasture ground for thousands of cattle) from 1847 to 1849, were not strengthened, but merely patched up here and there, wherever the weak section invited the flood to breach them.

From 1847 to 1849.

From 1849-50 to 1850-51.

2. Again from 1849 to 1851 not even patchwork was resorted to, the embankments were left unrepaired (one half of the mileage being struck out), so that the abandonment or retention of embankments remained an open question during five years, in which period, the sections deteriorated from natural causes; indeed if a building is left for five years without repairs in such a climate as Orissa, its stability is endangered; then how much greater must have been the deterioration of earthen embankments.

From 1850-51 to 1852-53.

3. The magnitude of the deterioration was not even known to the authorities, indeed, not even to the officers; for none visited (in the sense I intend) the protective works, owing to the frequent changes; and it

was only in 1852-53 (vide 24th para. of my report) that the first great test was applied which resulted in 1167 breaches.

4. Thus from 1847-48 to January 1853, (date of my joining as Officiating Executive Engineer), the Military Board had not decided definitely, on either abandonment or retention of embankments, but the superintending Engineer and others had given their orders (which were acted upon) to abandon one half, and not repair efficiently the remaining half.

From 1853-54 and 1854-55.

5. I conceive the Board could not get over the fact of Messrs. Ricketts and Mills having recorded that the Government were bound to keep up the embankments, and therefore no order was issued, but when the Superintending Engineer submitted (as I suppose to have been the custom) memoranda of his orders issued to Executive Engineers, the Military Board may have perceived that one half of the "so-called" useless embankment had been abandoned, and I can trace no order from the Board either sanctioning or cancelling the proceeding.

6. However, when the evil was past remedy, and the main river had left its channel to devastate the province to the south and south-east, another Superintending Engineer, Lieutenant-Colonel Goodwyn, enquired "why the embankments were in such a disgraceful state," and the answer will be found in the 20th para. of my report. As far as energy and a desire to correct the evil could go, measures were taken by me as per nature of orders then in force, but the day for such measures had passed; it was an attempt to fill broken pitchers, and was a hopeless effort to combat against volumes of water, which could only be controlled at the first spring, as pointed out by me in January 1855.

1855-56.

7. From January 1855 to January 1856, Lieutenant Harris was Executive Engineer of the Cuttack division (central and southern), with Mr. Rayner in detached charge of the southern division, and the chief work done consisted in filling in the breaches of 1854-55 (or as many as could be, as per statement annexed to my report) as per nature of orders then in force.

1855-56.

8. The extraordinary flood season of 1855-56 (the highest on record) again devastated the district, vide 35th para. of my report, and Lieut. Harris

was detached to survey and take levels in February 1856, and made over charge to Mr. Rayner. The nature of the orders then in force were to fill in the breaches, which was done to the extent shewn in statement annexed to my report.

1856-57.

9. Mr. Rayner remained in charge from February to September 1856, filling in breaches; and the floods of 1856-57, rolled down during his incumbency, causing 404 breaches.

No. Dated

10. Mr. Rayner was relieved of the southern division by Mr. MacGuinness on 1st October, 1856, retaining charge of the southern division; and the work carried out by both these officers in 1856-57, consisted in filling in breaches and strengthening sections as much as possible, as per nature of orders in force; and for information relative to all work beyond breach-filling, I would refer you to Captain Beadle's report.*

Whence the orders emanated.

11. Thus the nature of the orders in force from 1851-52 to November 1855, consisted in filling in breaches and strengthening weak sections; and the nature of the orders in force since November 1855, was detailed in 2nd para. of my letter No. 246 of 28th May, 1857, as per extract annexed; and the orders emanated from the Chief Engineer and the Government.

To what circumstances it is to be attributed that, in spite of the large increased expenditure in the bunds, the number of breaches is greater than in former years.

12. The increase in the number of breaches in the central Cuttack division, is owing to the fact of the embankments having been neglected for years, so that, when reduced in section, they are unequal to withstand the action of the extraordinary seasons of flood since 1853-54; and similar neglect in the southern division necessarily weakened the section of the embankment, owing to which, from being much heavier and opposed to greater volumes of water (which ought never to have been allowed to find their way to the south and south-east), larger breaches and proportionate expenditure resulted; and the number and size will continue to increase yearly, unless the Mahanuddy channel is re-opened to carry off its proper quota of flood.

Why the embankments have deteriorated from 1847 to 1857.

13. I have endeavoured to shew this in my report, and again in 1st para. of this letter, and believe that no better or truer reason can be assigned.

14. This I have written for to the Cuttack office, the labour will be shewn, the materials having been obtained from the Fort Barrabuttee, but stone is now no longer available, unless the scarp and counterscarp be dismantled, so that, every year (in future) the Government will feel the drain upon the finances, if stone is to be brought from Naraj for repairs.

Expenditure incurred in revetment from 1851-52 to 1856-57.

15. I requested the Commissioner, in my letter No. 964 of the 3rd instant, to furnish me therewith; failing which, I cannot, I regret, submit the valuable information.

Remission of revenue from 1843 to date.

16. Lieut. Harris, as already stated, had charge from December 1854 to January 1856, and did his utmost to close breaches, so did also Mr. Rayner and Mr. MacGuinness, and considering that the filling in of breaches of 1855-56 alone amounted to 26 miles of new embankment, averaging 10 to 15 feet in height, the actual work done (whatever the utility of the same may have been under the altered circumstances) shewed great energy, and no blame is to be attached to the Executive department.

Information regarding officers who have had charge since December 1854.

17. No officer could have taken a greater interest in or laboured more than Captain Beadle to further the interest of the province, and, fearless of responsibility (when he saw the means of contending against the root of the evil), he issued orders, as detailed in the 44th and 45th paras. of my report (but without any results), as he knew but too well that the interests of the province would be shelved, until the result of the operations of Lieut. Harris's survey and levels were made known. Lieut. Harris having worked with large embankments for two years, I took upon myself (agreeably to the verbal communication held with Officiating Chief Engineer at Calcutta prior to starting for Cuttack) the grave responsibility of keeping him to his special work (instead of placing him again in charge of the central Cuttack embankment division), which would have enabled him, by September or October, to have submitted his plans and reports for the final decision of Government. Although the step taken by me may have appeared irregular, it was founded upon a thorough knowledge of circumstances, and a conscientious conviction that it was the

What orders or instructions issued by Captain Beadle during his superintendency, and what officers worked under him.

only means available to ensure the interests of Government; however Lieut. Harris has been since sent away on service, leaving it problematical whether any return will be given to the Government for the money and time given up to provide special information, without which the Government is not prepared to adopt measures for the future security of the province.

Extract from letter, No. 246, dated 28th May, 1857, from the Officiating Superintendent of Embankments, to the Officiating Chief Engineer, Lower Provinces.

2. It is true that time has been lost by my not proceeding at once to Cuttack, but considering the very positive orders issued by Chief Engineer (vide extract annexed) as far back as November 1855, that no work was to be carried out in the Cuttack division except breach-filling, and that the utility of this measure was even doubtful, indeed that positive instructions could only be given, when certain information was provided from the results of the survey and levels to be taken by Lieut. Harris (which information has not as yet been provided), moreover when these orders were approved of by the Government, it ought not to be a matter of astonishment that the province is expected to be desolated, when two seasons have been allowed to pass without even an attempt to remedy the evils proved by me to exist so far back as 1854-55, vide my detailed report.

From Captain C. B. Young, Officiating Chief Engineer, Lower Provinces, to the Secretary to the Government of Bengal,—(No. 4140, Fort William, dated 12th October, 1857.)

Sir,

I have the honor to forward, for the information of Government, the annexed copy of a letter No. 1305, dated 7th September, 1857, from the Officiating Superintendent of Embankments, with accompaniment from the Executive Engineer, Pooree division of embankments, reporting the extent of the first flood of 1857-58, and the damage caused thereby in the southern province of Cuttack.

2. I also add a tracing of the rivers in southern Cuttack, therein referred to, for reference.

3. Pending the receipt of further reports on the flood and damage done in other parts of Cuttack, and with reference to my letter No. 3656, dated 19th ultimo, submitting Captain Short's report on the cause of the breaches in the embankments of Cuttack, I refrain from offering any remarks at present, except in so far as to direct attention to those parts of the Executive Engineer's report, in which it is stated that the breaches have been caused by the villagers themselves.

From CAPTAIN W. D. SHORT, Officiating Superintendent of Embankments, Lower Provinces, to CAPTAIN C. B. YOUNG, Officiating Chief Engineer, Lower Provinces,—(No. 1305, Midnapore, dated 7th September, 1857.)

SIR,

I HAVE the honor to annex copy of a report from the Executive Engineer of the southern or Pooree division relative to the damages by the first flood of 1857-58, and to refer you to the 18th, 19th and 20th paras. of the memorandum submitted by me in February 1855, since which period nothing remedial having been attempted, the evil has yearly increased.

Vide Lithographed report in Cuttack.

2. As the greater part of the estates are held *khas*, remissions must be made for the damage sustained. The sudder jumma is 469,277, and Rupees 60,000 in 1855-56 and Rupees 50,000 in 1856-57 have been expended in raising and strengthening embankments to secure this revenue, and the result is very unsatisfactory; indeed, the Government cannot afford to throw more money away on the southern division, without *first diverting the floods into the Mahanuddy*, for one half of the province *only* is cultivated, and the revenue would be doubled if the other half was so, by being rescued from the evils of inundation and drought.

3. The impossibility of passing off the volume of flood of 1854-55 through the embankments without breaching them, was pointed out by me in 1854, and I shewed (vide annexed abstract of Superintendent of Embankment's report) that under the *then* existing circum-

stances (that is without controlling the floods at head of Delta) there was no safety to the southern province, unless the Bargovee floods (pent up at the angle opposite to the Toraneah Bungalow by the volume of spring-tides from the Chilka) were relieved by the removal of the embankment on left bank of the Bargovee, and free vent given them into the Sur lake, and thence, through a channel existing, into the sea, east of Pooree.

Vide Lithographed map B. outline of Pooree division.

4. Mr. Rayner's 2nd para. bears out the statement in my report (lately furnished) that the Chilka or sea floods, rushing up the Bargovee, act as a complete barrier to the egress of even an *ordinary* flood, and that with a flood similar to the present one and that of 1854-55 or 1855-56, the highest embankments are topped and enormous breaches occur, swamping the country, and sweeping away villages with their inhabitants; and if this is allowed to continue, the cultivators will decamp.

5. Mr. Rayner's 2nd para. most fully coroborates my reports of 1853-54 and 1854-55. Anything more unsatisfactory cannot well be conceived than embankments 10′ high, and of strong section, being immersed and breached. I shewed (as Executive Engineer) that even in the dry season, a heavy sea rolled into the Chilka, and passing up the Noon, overflowed the banks and rose on the exterior slope, which was one half cut away by the action of the body of water lashed against it by the strong monsoon;—then, how much greater must the evil be with the Chilka at spring-tide level, with heavy floods attempting to force their way down the Dyah and Noon channels; indeed, the fruitless attempt, *both seasons,* to raise these embankments, has been so much money thrown away.

6. Mr. Rayner's 3rd para. describes 8 breaches in the Kokai or head of main southern channel, the floods having doubtless swept the pergunnahs situated on either bank. The channel cannot pass off so great a volume, *hence* the breaches, and orders will be issued to remove the village situated to exterior, agreeably to embankment regulations.

7. The effects of the breach described in 5th para. have to be seen, to be understood, and considering that 4 pergunnahs were swamped (the crops probably gone, hundreds clinging to the thatch of their roofs, with the whole of the heavy embankments on the Sur lake and Bengai nullah, &c. immersed), I would venture to hope that the

Supreme Government will come to some immediate decision, to enable the departmental officers to provide against greater, because increasing, evils.

8. The effects of the breach described in the 5th para. of Mr. Rayner's letter, must have been disastrous, the whole country between the Bargovee and Soonamoee must have been swamped, and the embankment on right bank of latter river taken in rear. The embankment may have been cut, but I attribute the occurrence of these breaches in the same locality to the new embankment having a sandy foundation, through which the flood percolates, and considering that to the interior, the country is several feet under water, a slip leads to a breach.

9. The climax of disaster is described in Mr. Rayner's 6th para., embankments 15 feet high and of strong section topped and breached, *one breach* 2,000 *feet long* (measuring nearly half a mile).

10. The fact is (vide annexed abstract) the Dyah cannot pass off the flood; indeed I suspect that the river has left its bed through the Neepore breaches, and made direct for the head of the Noon river, swamping the whole of the country between the Pooree road on the east, the Noon river to the west, and the Bargovee to the south, and these evils are entirely owing to the authorities not arriving at some decision during two and a half years, as to the most effectual mode of diverting the Mahanuddy into its legitimate channel.

11. The reason of there being no breaches in the escapes (vide Mr. Rayner's 7th para.) is owing to the main volume having passed through the embankment and spread itself over the country, and as the embankments on the Bengai and Sur lake were lost to view, *after having been raised* 3 *feet above supposed flood level*, I have merely to remark on the inutility of spending any money without first diverting the floods.

12. I believe that as regards both duration and height of flood, the province has never been visited with such a volume of water, as described both by Mr. Armstrong (vide his diagram submitted with my No. 1274, dated 4th September, 1857), and Mr. Rayner in his 9th para., and the results will be known when the Collectors of the districts furnish the extent of damages to crops, &c.

Mr. Rayner is a good practical officer and having, like himself, been out during the flood seasons, the conclusions arrived at are in some points similar, viz.:

No. 1 Was advocated by me in 1854, and is now imperatively necessary to save the southern provinces next year, and must be done at once, independently of the measures at the head of the Delta, and you will find it clearly marked out in the plan lately submitted with my report, and I beg your views and decision thereon, as I am confident it is a good practical move.

No. 2 Not necessary, as the Government will *certainly* determine to divert the Mahanuddy flood, when the southern division will be preserved.

No. 3 Not required, as no water will go down the Barung nullah when the head is closed and the very retired line (vide my plan) executed, and these will be relieving channels for the surplus water of the Kokai to pass up.

No. 4 Strongly recommended by me in 1853-54 and 1854-55, vide my report, and should be done at once, but a sluice given of three openings, to pass off drainage.

No. 5 Strongly urged by me in 1854, and is absolutely necessary (vide annexed abstract), the levels and report thereon will be submitted early.

No. 6 Strongly urged by me in 1854, indeed it is now a matter of necessity, and no more money must be in future thrown away. A sketch will be submitted, shewing the embankment to be abandoned, and the new embankment to connect the Noon and Dyah river lines.

No. 7, The damages in the south-eastern portion of the district have yet to be reported upon.

No. 8, When the floods are controlled at head of Delta, as urged by me, there will be no necessity to raise the embankment as proposed by Mr. Rayner.

From Mr. G. Rayner, Officiating Executive Officer, Pooree Division of Embankments, to Captain W. D. Short, Superintendent of Embankments,—(Camp Surdaipore, dated 26th August, 1857.)

Sir,

I have the honor to report upon the flood of the present year, as far as regards my personal knowledge of it, and its effects.

2. On the 8th instant the Bargoyee river began to rise, and by the 11th instant was topping all those embankments which have not

been raised 3 or 4 feet during the last two years. This rise was caused by the spring-tides in the Bay of Bengal and the Chilka lake stopping the progress of the rain drainage, and before this rise had subsided, the rain flood from the Mahanuddy (which at Cuttack was above 27′, nearly equal to that of 1855) came down and produced a greater flood on the lower parts of the Bargovee, Noon and Dyah rivers, than was ever before known.

3. The Noon river embankments have been raised to an average height of 10′, and were this year put into very good order and the turfing completed, but those and all others in the vicinity were on the 15th instant completely under water. The ground on which the Sanpara Bungalow is built, is higher than that of the adjacent village, and that was never known to be approached by previous floods, but this year the village has been washed away, and the flood rose two feet up the plinth of the Bungalow. Those of the villagers who had boats took to them, and the others floated about on the roofs of their huts. The out-offices of the Sanpara Bungalow are greatly injured, and so would the Bungalow have been, but that its foundation and plinth are of pucca masonry.

4. Other portions of the division have suffered, though not to so great an extent. The Kokai embankments have been breached in about eight places, and two are supposed to be cuts. Both places were in good order on the 29th ultimo when I inspected them, and as both places are much raised above what they were in former years, and rather retired, it can only be supposed that they occurred by cutting. The motive for the cut at Kacheramal is said to be malice on the part of the people of Naihapatud. The motive for a cut at Tankparra is evident, there is a village outside the embankments.

5. There are but two important breaches on the Bargovee, and at Parbuttypoor, the old sluice having given way, a breach has been the consequence. The platform was nearly on a level with the bed of the river, and with that, the cultivators were not satisfied, but had dug a channel so low as to expose the foundation, and yearly the sluice had to be repaired. I can vouch for its having been repaired this year, and as the villagers are often tampering with the sluices for fishing, &c., they may have done so with this, and thus have caused the breach. Whatever may have been the cause, the effects are very serious, for the water from this breach has flooded a large portion of four pergunnahs, and joining the Sur

lake, has completely hidden the embankment of that and Bengai nullah.

6. The other large breach is at Couplesarpur, in an embankment of very strong section, being 13′ high, 8′ crest and slopes 3 and 4 to 1. The embankment was not topped, and the breach took place in nearly the same spot (in the night time) that breaches have occurred yearly. I crossed over the flooded portion of country on the 26th ultimo, to examine the new line on the Puttuncheera, and remarked that there was no land cultivated. I asked the reason, and was informed that the Collector would not permit any cultivation unless the zemindars repair their bund. The rumour now is, that the Deputy Collector becoming aware of the non-cultivation of the land, threatened to impose the tax whether they cultivated or not, and the villagers, to save themselves from the impost, have made the breach. What truth there may in this statement I cannot say, neither can I account for the breach in any other way, than that the embankment was cut.

6 A. The floods on the Dyah have been very destructive: embankments 15 feet high have been topped, and ramps 2′ high had to be raised to prevent the flood going over. At Neepoor there are three breaches, one of which is about 2000′ long. This occurred on the 15th instant, I was at Neepoor on the 28th ultimo, and can vouch for the very excellent manner in which this new line was completed, under the supervision of the Rajah's Moonshee. It has been raised by layers and well consolidated throughout, it had a crest ten feet broad with slopes 3 and 4 to 1, and was piled with strong stakes on either side, but unable to withstand the combined force of a stoppage by the spring-tides, and a storm on the Chilka, and the effects of the floods of the Dyah and Gungird rivers.

6 A. The latter river flows nearly parallel to the Kokai and the Dyah, and falls into the Dyah near Kunttee. It is fed by the waters of several hill streams, but the main portion of its flood appears to come from the Mahanuddy, by the Barrung at Mooterree or even higher up. Its floods have been the cause of the breaches on the Baithbuddra and Dyah for several years past. The country to the right of the Dyah as far as the hills is even now one sheet of water, and the current stream of the Gungna running with greater velocity than the Dyah, into which it has formed two new discharging channels within these last three years.

7. There are no breaches on the Ronchee, the two Kanias or the Soonamohee, and there are two on Ruttancheera and one on the Dawrid. But the embankments of the Noon and Sur lake are so much under water, that it is difficult to say what breaches may be in those places.

8. Independently of the severity of the flood, it has likewise been very injurious from the length of time it has continued. It commenced on the 8th instant, and it was only yesterday, the 25th, that it subsided materially. This again shews the effects the spring-tides have on the rivers. On the 19th there was a change in the Noon, and three days afterwards there would be spring-tides, and thus on the 22nd and 23rd instant, though the rain flood was subsiding, the rivers were rising, but yesterday and to-day the rivers have been falling rapidly.

9. Before the flood, I had brought the most of the field establishment into Cuttack to close their accounts, and discharged them according to your orders, but seeing the rivers rising, I immediately despatched them to their sections, where I had previously sent bags to be ready in case of necessity, and many breaches were thereby prevented.

10. It is very evident that the Pooree district has to bear a much larger share of the flood than belongs to it, and that, without the means of getting rid of it as quickly as it comes: of course the closing up the head of the Mahanuddy, and the reduction of the points at Chargureah, tend much to produce these excessive floods.

11. I know not what means are proposed by the river survey department to relieve the Pooree district, but in my opinion, the following should be adopted without delay.

(1.) Close up the head of the Barrung nullah.

(2.) Continue the sandbanks at the head of the Kokai to right bank by piling.

(3.) Continue the embankments of the Barrung, the Bhord and Baithbuddra nullahs, two miles or so farther up.

(4.) Close the tail end of the Kandred nullah.

(5.) Open a communication between the Sur lake and the Bay of Bengal by self-acting sluices.

(6.) Give up the Noon river embankments as far as Tigerid, and have a new line from thence along the high ground to the Dyah embankments.

12. To which may be added that no restriction should be placed on raising and strengthening the embankments throughout the division.

13. Of the Katjooree, Suria, Deb, Tumprid, Allanba, &c., I can at present make no report, but will, as soon as I inspect them.

From CAPTAIN C. B. YOUNG, Officiating Chief Engineer, Lower Provinces, to the Secretary to the Government of Bengal, Fort William,—(No. 5364, dated 1st December, 1857.)

SIR,

IN continuation of my letter, No. 3656, dated 19th September, 1857, I have the honor to submit the annexed copy of a letter, No. 1725, dated 30th November, 1857, from the Superintendent of Embankments, with report by Mr. Armstrong, on the effect of the floods of last season upon the district of central Cuttack.

2. The present report completes the subject of the breaches in the embankments of the Cuttack division, caused by the rains of the present year. It includes a portion of the Balasore division of embankments as well as central Cuttack, and embraces the floods of the Brahmany and Byturnee, as well as of the Mahanuddy and Katjooree.

3. The result, tabulated by Mr. Armstrong in his 30th para. is to the effect that the sum of Rupees 34,429 will be required to repair the bunds in the central and northern divisions. Reports from Mr. Rayner, the Executive officer of southern Cuttack, show that the sum which will be required in his division amounts to almost 53,000. The total for the whole of Cuttack therefore is Rupees 87,429.

This is exclusive of Rs. 33,000 spent between the 1st May, 1857, and the rains of the year.

4. The table given at para. 4 of my letter, No. 3656, dated 19th September, 1857, on the cause of the numerous breaches in Cuttack will show, that the average annual cost of repairs since the year 1840, excepting two years 1849 and 1850 when the repairs were designedly neglected, has been about 47,000 Rupees. For the last few years from 1854-55, it has been considerably more, and in the year 1855-56 amounted to Rupees 120,789.

Statement of remissions granted and expenditure incurred on Embankments in the three districts of the Cuttack Division, during the 23 years from year 1834-35. *The former furnished by the Board of Revenue in their No.* 435, *of* 11*th November,* 1857.

Years.	District.	Revenue remitted. Detail.	Revenue remitted. Total.	Expended on Embankments.	Total remitted and expended.
1834-35.	Cuttack,	1,94,363 14 3¼			
	Pooree,	0 0 0	1,94,363 14 3¼	... ...	1,94,363 14 3¼
	Balasore,	0 0 0			
1835-36.	Cuttack,	0 0 0			
	Pooree,	3,872 5 7	3,872 5 7	... ...	3,872 5 7
	Balasore,	0 0 0			
1836-37.	Cuttack,	2,80,232 7 7			
	Pooree,	1,08,256 8 7¼	5,42,293 5 11¼	... ...	5,42,293 5 11¼
	Balasore,	1,53,804 5 9			
1837-38.	Cuttack,	0 0 0			
	Pooree.	0 0 0	10,184 7 11¾	... ...	10,184 7 11¾
	Balasore,	10,184 7 11¾			
	Carried forward, Co.'s Rs.		7,50,714 1 9¼		7,50,714 1 9¼

Year.	District.	Revenue remitted. Detail.	Revenue remitted. Total.	Expended on Embankments.	Total remitted and expended.
	Brought forward, Co.'s Rs.		7,50,714 1 9¼		7,50,714 1 9¼
1838-39.	Cuttack,				
	Pooree,	50,791 0 2	50,791 0 2	... ...	50,791 0 2
	Balasore,				
	Cuttack,	3,73,106 15 8¾			
1839-40.	Pooree,	2,02,842 0 9¼	7,64,222 4 6¾	... .	7,64,222 4 6¾
	Balasore,	1,88,273 4 0¾			
	Cuttack,	2,09,342 14 4½			
1840-41.	Pooree,	1,70,271 13 10	4,98,262 8 5½	27,721 11 8	5,25,984 4 1½
	Balasore,	1,18,647 12 3			
	Cuttack,				
1841-42.	Pooree,	... .	... ...	10,109 15 4	10,109 15 4
	Balasore,				
	Cuttack,				
1842-43.	Pooree,	10,858 13 4¾	10,858 13 4¾	19,250 2 8	30,109 0 0¾
	Balasore,				
	Cuttack,				
1843-44.	Pooree,	8,828 11 9	8,828 11 9	21,317 8 6	30,146 4 3
	Balasore,				
	Cuttack,				
1844-45.	Pooree,	2,154 10 7	2,154 10 7	20,215 12 3	22,370 6 10
	Balasore,				
	Cuttack,				
1845-46.	Pooree,	30,672 7 1¼	42,259 13 10¼	32,122 13 10	74,382 11 8¼
	Balasore,	11,587 6 9			
	Cuttack,				
1846-47.	Pooree,	8,666 14 6	8,666 14 6	15,791 13 10	24,458 12 4
	Balasore,				
	Cuttack,				
1847-48.	Pooree,	814 10 3¾	814 10 3¾	18,929 8 9	19,744 3 0¾
	Balasore,				
	Cuttack,	2,467 3 2¼			
1848-49.	Pooree,	4,404 13 6	34,913 7 11¼	20,132 7 11	55,045 15 10¼
	Balasore,	28,041 7 3			
	Cuttack,				
1849-50.	Pooree,	... .	... ...	3,979 10 10½	3,979 10 10½
	Balasore,				
	Cuttack,				
1850-51.	Pooree,	769 9 1	18,465 4 8	1,604 11 7½	20,070 0 3½
	Balasore,	17,695 11 7			
	Cuttack,	5,227 12 2½			
1851-52.	Pooree,	12 15 11	50,786 14 2½	20,401 1 8	71,187 15 10½
	Balasore,	45,546 2 1			
	Cuttack,				
1852-53.	Pooree,	42,346 3 11¼	42,346 3 11¼	17,317 5 8	59,663 9 7¼
	Balasore,				
	Cuttack,				
1853-54.	Pooree,	22,209 8 3½	69,276 10 7½	33,891 14 0	1,03,168 8 7½
	Balasore,	47,067 2 4			
	Cuttack,				
1854-55.	Pooree,	52,839 15 10¾	69,759 11 1¾	56,682 1 7½	1,26,441 12 9¼
	Balasore,	6,919 13 3			
	Cuttack,				
1855-56.	Pooree,	21,669 15 5½	21,669 15 5½	1,20,789 6 9¼	1,42,459 6 2¾
	Balasore,				
	Cuttack,	31,442 8 6½			
1856-57.	Pooree,	27,499 15 11¼	58,942 8 5¾	57,576 12 9	1,16,519 5 2¾
	Balasore,				
	Total Rs.		25,03,734 5 9¾	4,97,834 15 8½	30,01,569 5 6¼

5. The height of the floods registered on the Lallbaugh gauge at Cuttack during the last three years has been as follows.

1855, ... 127.13 feet above datum
1856, ... 123.48 „
1857, ... 126.68 „

Yet notwithstanding that the flood of the year 1856 was the lowest on the gauge, it is stated by Mr. Armstrong to have been the most detrimental to the crops of the country, because it was of greater duration, lasting 17 days, and thus rotting and ruining them. If only submerged for a few days they do not materially suffer, but recover as soon as the waters flow off again.

6. The height of the Cuttack floods depends much upon the state of the sea tides at the critical time, particularly in south Cuttack, where the Chilka lake under the influence of gales from the eastward, exercises a considerable influence upon them. Their duration depends more on the rain falls in the upper districts or drainage areas, and when inundations occur consequent on breaches, the injurious effect of these is increased, as explained by Mr. Armstrong in his 18th para. by the obstacle which the bunds themselves present, to the vast sheets of water which they have failed to exclude, flowing off again. This, the water can only do through the breaches themselves, and it is impeded not only by the limited openings the breaches present, but by the natural fall of the ground which in this, as in all cases, is from the river bank towards the interior.

7. Before the floods of the present year occurred, apprehensions were entertained, that owing to the increasing volume of water which appeared to be yearly passing down the Katjooree or south breach of the Mahanuddy, the southern provinces of Cuttack would suffer more than the central and northern from inundation. This does not appear however to have been the case. The floods seem to have been equally violent in both portions of the province. Higher embankments it is true have been topped in south Cuttack but this, according to the executive officer's report appears to be owing to the fact that high spring tides from the sea and a storm on the Chilka lake, occurring simultaneously with the floods, very naturally influenced and augmented them.

8. The drainage no doubt has been great in south Cuttack, but in submitting the present report from Mr. Armstrong, the Superintendent

of Embankments observes that it is "difficult to conceive a worse state of things" than that described therein. I can see no reason therefore for concluding otherwise than that the floods of this river are pretty equally divided between the two main channels, the Katjooree and the Mahanuddy.

9. The quantity of water discharged by the main river, the Mahanuddy, in the rains, is so enormous, being more than three times the volume of the Hooghly or three quarter millions of cubic feet per second, the streams into which it subdivides itself, and which intersect the Delta in all directions are so numerous, and the velocity of the current so great, that changes in the channels are frequent. Hence, while some embankments become of no use owing to the desertion of one channel, those on another and hitherto insignificant one, have to be enlarged and heightened to withstand the increased and unexpected floods which assail them, and are not unfrequently undermined and altogether swept away, being in no way adapted to the altered state of the river on the banks of which they were first constructed.

10. There can be no question that in their present condition, the embankments of the province are quite ineffectual to protect the country from inundation, and the crops too frequently from destruction. These crops consist chiefly I believe of rice, which cannot be raised without a plentiful supply of water, but which, with too much, decays and is destroyed.

11. From the earliest times, Cuttack has suffered almost annually from either drought or inundation. A glance at the table given at para. 4 will show the large sums, which have been regularly expended by the Government on the repairs of the embankments, and which have also been lost to them in the shape of remissions from the revenue. The question now under consideration is:

1st. Whether it is possible to remedy this state of things by Engineering works constructed at the head of the Delta, with the view of regulating the distribution of the flood waters, as has been proposed by several Engineer officers lately connected with the province.

2ndly. Whether the embankments throughout the province should be placed in a thoroughly efficient condition; to do which, they must be amply supplied with sluices; or

3rdly. Whether it would be better to leave them and the river alone, and allow nature to take her own course.

12. With regard to the first, the works on the Madras presidency rivers, have been cited as examples for imitation. These, however, arrest and bank up the dry weather stream of their respective rivers, and the body of water thus stored up, is made available for irrigation during the dry weather. They do not attempt to control the rain floods which pass over them to the depth of ten or twenty feet, and all that is expected at such times is, that they shall withstand the torrent of water uninjured. They are not, that I have ever heard, supposed to have the least influence or control over it.

13. If the object of the masonry works proposed therefore by Captains Beadle and Short, and Lieut. Harris, above Cuttack be to regulate the flood waters, they would, in my opinion, be altogether ineffectual for this purpose. The waters of the Mahanuddy which in the rains rise to a height of thirty-eight feet, while the highest dam proposed is only twenty-one feet above the bed of the river, would not only be uninfluenced in their course, but unless the works were very carefully and solidly constructed in the usual manner of anicuts, they would completely destroy them.

14. Again, if the object were to obtain irrigation in the dry weather, it is still more necessary that the dams or weirs should be built after the model of anicuts, that is, completely across the river, which is thus ponded up until its waters accumulate in a still pool behind the anicut to the depth necessary for the purposes of irrigation. As I find in none of the projects or papers that have been submitted, the calculations necessary to determine the height of such a dam or the distance from it seaward, at which the water would become available for irrigation, I conclude this has not been in any case the intention of the projectors.

15. One of the first points which it is necessary to determine, however, is this very one, viz., whether the province of Cuttack requires irrigation. The climate and seasons are different from those of the Madras presidency. Cuttack is under the influence of the south-west monsoon and has a regular rainy season commencing in June. The Madras provinces on the Coromandel Coast have no rainy south-west monsoon, but have their rains with the North-East monsoon, commencing about the middle of October.

16. Although therefore irrigation or water for the crops would no doubt be desirable in the hot weather in Cuttack, as every where

in India, it may be a question with reference to the nature and state of the crops at that season, whether it is of such value as to justify the construction of very expensive engineering works to obtain it from the river Mahanuddy.

17. And it is still farther an undetermined question, whether considering the great height of the banks of the Mahanuddy or depth of its bed, these works could be constructed (without being of a more than ordinarily expensive and precarious nature) so as to bank up the dry weather stream to such an extent, as to make its water available for irrigation (that is the point of striking out of the water on the surface) at a reasonable distance from the sea, and such as would, by the amount of cultivation created, compensate for the expense incurred.

18. Cuttack is about 50 miles from the sea, and of this distance, 20 miles on the seaboard are so low, as to be subject to sea inundation. There remain but 30 miles, and nearly the whole of this would probably be lost before the water could be brought to the surface. The dam or weir proposed to be constructed by Lieut. Harris at Naraj above Cuttack is 21 feet in height, and its crest is 17 feet below the flood level of the river, which reaches to nearly the top of the bank. If the fall of the country be 21 inches in a mile (until Lieut. Harris's levels are checked and submitted, it is impossible to say exactly what it really is) and if the water in the irrigation channel have a fall of only 12″ in a mile given to it, it would take 23 miles before the bed of the irrigation cut could be brought to the surface, and little less (say 20) before the water itself could be available.

19. It is a question therefore which appears doubtful, whether irrigation works of the nature adverted to are required, or could be constructed with profit and advantage for the province of Cuttack.

20. I have already said that to attempt to control the inundation floods of the Mahanuddy, which are of three times the volume of the Hooghly, or 1800,000 feet per second, by any such dams as those proposed, would be, in my opinion, quite impossible.

21. The bunds may be placed in a thoroughly efficient and perfect state, so as to preserve the country altogether from inundation. This would without doubt involve a very great expenditure, particularly as numerous sluices would have to be constructed. If this were not done, the bunds would be cut by the villagers to obtain water, a

practice which is of common occurrence now, and which is several times adverted to in the report of this year from the executive officer of the southern Cuttack division, submitted with my No. 4140, dated 12th October, 1857.

22. This practice is even systematized by the villagers, that is, they insert a hollow trunk of a tree in the embankments where they wish to obtain water, and carefully conceal it from the executive officers, with earth and turfing. Through this at the desired time they obtain the water they require, and take their chance of a breach occurring and of discovery. This water, as they say, is life to them; for without it, they could not rear their crops or pay their revenue, and the darogahs are paid to connive at the practice, while in case of discovery, some one villager, whose family is during his punishment and imprisonment supported by the rest, is voluntarily made the scape-goat. This, I am informed by the superintendent, is common, and that he has discovered many such hidden sluices at places where it appeared to him strange that breaches were constantly occurring at the same spot.

23. The bunds may be given up altogether and the rivers allowed to spread over the country wherever the level permits. Mr. Armstrong gives it as his opinion in his 18th para. and in this he says he is supported by Lieut. Harris, that "it would be more advisable, considering the natural construction of this country or district, that the embankments should be entirely done away with, than that ill-constructed works should remain." In his 32nd and 33rd paras. however he anticipates the time when Cuttack will be a fertile country, protected by efficient bunds, and when its "natural facilities for a work combining embankments, irrigation, and partial navigation" will be taken advantage of. What species of work Mr. Armstrong alludes to, I am unable to say, and he has not any where more clearly expressed himself.

24. Considering the "nature of the district," as Mr. Armstrong says, the crops of rice it chiefly produces, which require much water, but still that that water should not be injuriously retained on them too long nor rise to too great a depth, both which conditions the presence of bunds unprovided with a large number of sluices, tends to favor; considering also the facts stated in para. 6, I confess I am disposed to think, that it might be the best plan to cease repairing the Cuttack bunds and to allow the inundations of the Mahanuddy to spread over the land, until its whole level were raised higher.

25. The proposal has not yet been made in any report that I am aware of, unless it be about the years 1849-50, but I have reason to believe that, it has been in contemplation by more than one of the Government officers in Cuttack. There is I believe an impediment in the engagements of the Government to keep up the bunds; an engagement which I am told has still six years to run. If this be so, it is an insuperable obstacle, and there would appear to be no alternative but to continue the usual system for the present; in which case the expenditure for the official year on the Cuttack bunds will be approximately as follows.

For Nothern and Central Cuttack, ...	34,429
Southern Cuttack, ...	53,000
Total Rupees, ...	87,429

26. I should not conclude without adverting to Captain Short's proposal to remove the station of Cuttack and the Civil buildings to the ground on the left bank of the Mahanuddy. If such a measure as this be really entertained, I need scarcely say that it would demand very serious discussion, and that many advantages must be found in it, to remove the numerous objections which would doubtless be made.

27. It is not of course expected that in the present day, a city numbering some 50,000 inhabitants can be at once removed by order, and if the cantonments and Civil officers with their dependants are separated by a river at all times difficult to cross, and at some seasons impassable, there can be no doubt that much inconvenience, to say the least, would be the result.

28. The possibilities and advantage of such a measure, must be very clearly and incontrovertibly shewn by those who propose it. In the meantime if the bunds were abandoned, it is probable that the river floods would be so much relieved, that all fear of danger to the town, or at least to its principal buildings on the highest grounds, would be averted.

From CAPTAIN W. D. SHORT, Officiating Superintendent of Embankments, Lower Provinces, to the Chief Engineer, Lower Provinces, —(No. 1725, Midnapore, dated 30th October, 1857.)

SIR,

I HAVE the honor to annex a copy of Mr. Armstrong's interesting report on the damages inflicted upon the embankments in the central Cuttack division, with the map for easy reference.

2. The number of the several paras. of Mr. Armstrong's letter requiring comment, are entered in the margin for you to refer to.

3. Doubtless the lands within No. 13 section, are the most
No. 4. valuable, as yielding the greatest amount of revenue, but the lands comprised within No. 16 section as also No. 8 and part of No 14, have been seen by Mr. Armstrong after successive years of neglect and inundation; for the Patamoondee property was very well paying and well cultivated; but of late years, the excess flood down the Chota Brahmany from the main river, has breached and carried away most of the protective lines.

There is no question regarding the inefficient state of embank-
No. 5. ments, and their deteriorated condition is entirely owing to the causes shewn in my report.

The result of Mr. Armstrong's experience bears out fully my
Nos. 6 and 7. detailed reports upon these embanked districts, and by the time the correspondence on the subject is concluded, I am of opinion that the existing sections will have disappeared, or be traced out with difficulty by some future Executive viz., by the thin line of jungle covering lines of small mounds.

The cause assigned for the inefficiency of the embankments by
No. 8. Mr. Armstrong is good, as far as regards the *central* portion of the *central* division, but the embankments to the south-east of the central Cuttack division, and those in the southern or Pooree division, were never intended to withstand such volumes of water, nor were they subjected thereto; it is only owing to the inattention and ignorance of the great changes in progress at the head of the Delta, and the consequent yearly increasing volume of flood passing to the south and south-east, that the embankments have answered no useful purpose.

I agree with Mr. Armstrong and would point out that, since
No. 10. January, 1854, the order has been to "fill in breaches," and considering the work has been done, the question is, whether the district has benefited permanently? I believe property has deteriorated in value, simply because nothing has been even attempted at the right place, viz. at the head of the Delta, where efficient measures would soon restore the equilibrium of the floods.

The facts narrated are patent only to those who have remained out during flood season, seen the country inundated through scores of breaches, watched the flood rising on the crops, and judged of the loss according to the period of submersion, (for the injury is always greatest when the floods and spring tides are simultaneous, as there is at such periods no outlet).

Regretting as I do the state of things in the Cuttack district,
No. 17. and being convinced that the measures proposed by me in my report, or an improvement thereon; would be successful if attempted, I would particularly point out the practical view of the question taken by Mr. Armstrong. With well-paid Engineers and large establishments, it appears hard that the Government money should be squandered in breach-filling, instead of making the district a granary, whence to supply the less favoured districts on the Madras coast.

It is needless to follow Mr. Armstrong through the detailed information given for each charge, suffice it, that it is difficult to conceive a worse state of things, and in requesting your earnest perusal of the 32nd and 33rd paras. of the report, I request that the subject may be laid prominently before Government, not with the view of ascertaining whether money shall be spent in "filling in breaches" and "raising embankments;" but whether the only measure that can possibly afford relief, viz. a "weir to prolong the line of water-way of the Mahanuddy along the left bank below Naraj, and prevent the spill (immediately below Naraj) down the Katjooree" may be carried out, or at least, material collected for any measure considered more practical.

I have urged the removal of the collectorate and all public offices, as well as the cantonments, to the high plateau on the left bank of the Mahanuddy, where the Telegraph wire will run; and considering that the low level down the Katjooree is increasing, the Government ere long, in the natural course of events, will have cause to regret that

timely measures were not taken to avert the catastrophe or preserve property.

From T. W. ARMSTRONG, ESQ., C. E. Executive Engineer, Central Cuttack Embankments Division, to CAPTAIN W. D. SHORT, Officiating Superintendent of Embankments,—(No. 325, Cuttack, dated 24th September, 1857.)

SIR,

I HAVE the honor to submit a statement of the damages inflicted upon the embankments, in the Cuttack central division (including 2 sections of the former Balasore division, viz. Nos. 18 and 19) by the floods of this season.

2. A map on a scale of four miles to the inch shewing the whole of the sections in the Cuttack division, and No. 18 in the Balasore district accompanies this letter, to explain, as I hope, by a glance, the situation of each section and the rivers whose spill floods affect them. I can get no plan of ready reference for No. 19 section,* but this is immaterial, as it is the minor work of the others, and scarcely worthy of special notice at present.

* Since writing this para. I find I can shew No. 19 section on the plan I forward.

3. The sections of the Cuttack central division are as follows.

No. 8. Affected by Katjooree and Mahanuddy.

No. 12. Ditto by Katjooree and Kaneah rivers.

No. 13. Ditto Mahanuddy, Punkpaul and Pykah.

No. 14. Ditto Cheeturtollah (Bura and Chota) the Noon river and Millah, Patnullah, Gopee, Gobree, and Bagnee nullahs.

No. 15. Ditto Beropa, Mahanuddy, and Brahmany rivers.

No. 16. Ditto Bura and Chota Brahmany and Jumboo rivers.

Belonging formerly to the Balasore division.

No. 18. Ditto Kursooah and Byturnee rivers, Goongtee, Bugcharra and Keah and Bengy nullahs.

No. 19. Ditto Salindee river and Kuppally nullah and the bunds along sea coast or Ankoorah bunds.

4. At present I consider No. 13 section the most valuable in point of revenue, and Nos. 16 and 18 the least so, to these can be added part of No. 14 and which is that portion of it lying between Kendraparah and Patamoondee.

5. The Collector of Cuttack during the past year has made remissions in its revenue to the extent of Company's Rupees 31,442-8-6½ this chiefly occurred in Nos. 16 and 18 sections (speaking proportionally).

This loss of revenue and the present difference in value as I may call it, of each section, is entirely caused by the unsafe, inefficient and deteriorated condition of the embankments.

6. The soil and natural facilities for rice cultivation are of a more favorable kind in (part of) section No. 14 and Nos. 16, 18 and 19, this exhibits an unfortunate circumstance, which is, that where the embankments are least effective, the facilities for the cultivation of the soil and the good qualities of the soil itself exist in the greatest degree.

7. I do not write these remarks without due data. I have been a resident of Cuttack since May 1855, and since then have been all over the districts under notice, I have an intimate knowledge of every river and nullah, except those which affect section No. 19, and these are insignificant. To the result of my own observations, I add the universally expressed opinion, that nothing can be more unsafe (and it is a circumstance much to be lamented) than the embankments of this division.

8. I believe originally these works were constructed under native superintendence, unconnected, with reference one to the other, unworkmanlike and not permanent as regards figure and position, unprofessional to the eye, unsafe and to a great extent lessened in value, as regards strength of section, reference to flood-level, and stamina, to resist the action of the bunded floods of so many large rivers.

They have been repaired year by year nearly equal to their original condition, under an excess of native superintendence. Skilled labour has not been brought to bear upon them in any way, and the valuable supervision of an executive Engineer has had, in days gone by, so great demand upon it not alone from these embankments, but from the district roads and public buildings, that its distributed beneficial effect was almost lost, as regards the efficiency of the actual work executed, to repair these "leveés."

9. I find from office records that the expense of the Cuttack central division, excluding a proportion due to the supervision and annual outlay for repairs of works in the Pooree district and of the

Juggernauth road, for the periods both of these works were under a united superintendence, amounts for the past five years to about Company's Rupees 1,80,000.

10. The damages inflicted by this season's floods, and cost of superintendence for the year 1857-58, will probably amount to Company's Rupees 34,429-13-5.

11. I do not consider the embankments will be at all improved, speaking in a permanent sense, when the breaches now open are filled in and perfected.

12. There is no doubt that if a flood occurs next year, similar to any we have had for the past three seasons, great injuries will again take place. These three floods read on the Cuttack gauge* 127.13, 123.48, and 126.68. A considerable difference exists between the level of the 1st and 3rd and the 2nd of these inundations. However, it is not the height, but the duration of these floods that inflicts severest damage.

* At the Lall Baugh.

13. In 1855 the great flood of that year submerged nearly the whole country, and before overriding the embankments caused many severe gaps in them, yet the revenue of the Cuttack district lost absolutely nothing by its occurence, it having fallen as quickly as it rose.†

† And before it had time to cover the rice-fields with any extra depth of water.

It was the lengthened flood of 1856, which continuing at a certain and a high level for some sixteen or seventeen days,‡ that created those damages to the crops of the country which entailed a direct loss to the revenue of Company's Rupees 31,442-8-6½.

‡ Filling up all the basons and low grounds of the district.

14. The inundation of this season 1857 was of much longer duration than that of the "big flood" of 1855, but it did not reach the number of days the one of 1856 continued, yet as the breaches in the embankments have been very considerable in number and extent, and from reports I have received, it is stated that they were in many places quite submerged, I am afraid the subsidence of this flood in the river channels, left a vast area of water in the land side of the embankments unable quickly to flow off, thereby causing the rot and destruction of the paddy plant.

15. What the real results may be I cannot say, but present prospects present an unproductive season for the landholder, and unremunerative return to the ryot for the tillage of his lands, as also

upon the seed and labour he expended to raise his annual subsistence.

16. I arrive now at the conclusion that, at the present moment, the embankments in my charge have not been improved in any way, since their construction. That their condition has deteriorated I think there is no doubt: an inspection of them will prove this assertion, and their furrowed slopes, worn crests, and insecure position, from the erosion of the river banks they are built upon, will be evident. The two former have been chiefly caused by defective original construction, careless supervision by those in subordinate grades, inefficient repairs by unskilful workmen, and very possibly, the restricted Budget granted to the Executive Engineer in charge of the division.

17. You, Sir, are well acquainted with these works, and I need not enter into any more detail, besides this is not the time to enlarge upon the subject, or suggest remedies and preventions for the yearly losses to Government, which occur in this district; for I look upon a large percentage of the expenditure that has taken place, upon these radically defective works, and which comes under the head of "Annual Repairs," as so much money lost for ever. Year by year the expenditure goes on, nothing permanent is executed, what injuries happen in 1855 are repeated, be the same more or less, in 1856, and again 1857 tells the same tale. If these works were in the hands of private companies paying dividends, how could they do so, if a similar system to the one now in existence were adopted? Their capital would soon be exhausted upon the annual items of repairs, superintendence and office expenses.

18. It is my opinion, and in this I am supported by Lieut. Harris, that it would be more advisable considering the natural construction of this country or district, that the embankments should be entirely done away with, than that ill-constructed works should remain. When high floods occur, indeed any which uplift above a very low level, the embankments are topped and breached, and the flood-spill pours through these gaps with a considerable head. This, added to the supply from the overtopping of the crests of the bunds, quickly floods the lands inside of these levees, turning all the cultivated land into one unbroken sheet of water. When the waters subside in the main channel, the area of the breaches effected by the depth of the spill flood is inconsiderable, consequently the discharge

from these submerged lands into the half full river channel, is by no means proportional to that which passed through it from that artery, when it was in flood—besides, it is a well known fact that a river's bank is generally the highest level of comparatively level plain, and that the fall is almost certain to be found from the bank of the stream inwards; this is truly the case in this district as any of the cross sections across country from river to river, taken by myself or Lieut. Harris, will plainly exhibit.

19. I feel I have prolonged these remarks to too great an extent, and shall now particularize the damages which have happened to the works of the division this season. I shall take the sections consequently as they have been written down, and will only give the condensed result of the reports I have received myself, from the subordinates attached to my staff.

20. The first section No. 12* affected principally by the floods of the Katjooree, has 33 breaches, varying in length from 50 to 450 feet, and in depth from 2½ feet to 25. This latter, I should say, gives the depth of the scoop hole created by the rush of the flood spill, through the broken embankment.

* No. 8 being the town of Cuttack, Jobra bund, Lall Baugh, revetment and embankments will be separately reported on hereafter.

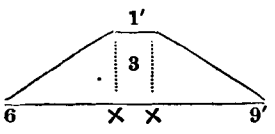
The total quantity of earth required as per rough estimate, to repair these 33 breaches amounts to cubic feet 16,55,279.

21. In No. 13 section effected by the floods of the Mahanuddy and Pykha rivers, I find that 112 breaches have taken place, the largest is 1850 feet long, 47 wide, and 6 deep. There is another 350 feet × 100 feet × 15 feet, all the others are of less size. Total area of breaches 22,000,62 cubic feet.

22. No. 14 section is the most extensive of any, and portions of it as I have mentioned, though nominally embanked, are not really so, as its bunds are, with regard to any large flood, useless.

105 breaches have occurred in these works, and the amount of earthwork which will be required to fill them is calculated at 50,00,000 cubic feet. I copy some extracts from Assistant Overseer Atkinson's report on this section, after the flood of August last. These extracts will give much detail with regard to the greatest accidents that the late inundation engendered.

"At the village of Banasorepore there are some breaches.



Section of bund. The people here say that they intend to leave the place and remove to another better protected from the flood.

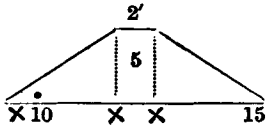
"Arrived at Kendraparrah bungalow, where the flood water has risen and covered the verandah floor, the out-offices all tumbled down, which were built in 1856-57. The top of the plinth can be taken for No. 30 flood-mark. The people here state that this season's flood is higher than any flood that has ever been before, which I firmly believe. I intend to visit the Noon nullah bunds, but I could not take my boat along it, in consequence of a bund having been placed across by the zemindars, and as the whole country is flooded I could not travel by palkee. Halted for the night at the bungalow.

"1*st September*.—Crossed the Noona river and proceeded to Hurryauk on the left bank of Polta nullah, where there is a large breach 220 feet long, depth 20 feet. Near the breach on the up-stream side, there is 170 feet of the river slope and crest destroyed. A Dobundee will be required at this place next season, which would require to run either through the village or in rear of it. If constructed in rear of the village, an embankment of 9 feet high and 3000 in length will be required, and if through the village, an embankment of 6' feet would be required, and 800 feet in length; but a number of houses would require to be removed, which the villagers would prefer. At the breach near this village the water has rushed through with great velocity, and has left a great deposit of sand on the land and made it almost barren. There was a large tank in rear of the village which has been entirely filled up with sand, brought through the breach. There is an embankment adjoining this breach 1470 feet in length, which was regularly topped by the flood but was saved by the zemindar, by sods being placed along its top. The whole length requires raising.

"3*rd September*.—Started from Poobhunsee to Pilurparra. On left bank of Pant nullah, a breach of 220 feet in length, and has a hollow about 30 feet deep and 120 feet broad. It was filled in 1856-57. At the village of Koolgowesalloo left bank of Pant nullah, there is a breach of 145 feet long, with a large hollow, and when repairing this breach, it would be advisable to take the new bund clear of it. At the village of Pancola, Pant nullah, left bank, there is a large breach of 250 feet

which has a deep hollow, that has been scooped out from the bank of the nullah for 4 or 500 feet. This breach was filled in 1856-57.

"At the village of Kaleeaboodah on the left bank of the Noona river, there is a large breach of 800 feet, depth 15 feet. Section of bund.



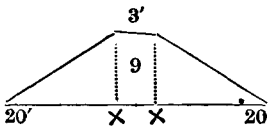
At the village of Khundsye left bank of Noona river, the bank has been eroded and in a great many places the embankment destroyed, for a distance of about 400 feet. There is a breach here 45 feet long, depth 4 feet. At the village of Balleapudda, and in continuation of the embankment of the last village, the river bank is eroded, and the exterior slope of the embankment destroyed. A retired line of bund 2170 feet in length, and six feet in height will be required."

23. In No. 15 section, the largest breach is 850 feet in length, 80 feet wide and 16 deep. Cubic area 10,88,000, this is fortunately nearly the only one of extent in the section, but it has caused severe loss in the neighbourhood. Its position at Judpore may be observed by reference to the accompanying map. The river bank here is high, the ground inside falling quickly away from it. When the embankment was overtopped, the scour of the flood along, I may say, this sharp incline, cut into the maiden soil so deeply as to cause the river bank to give way en masse as it were, and the rush and discharge of water through this large gap was consequently very great.

24. I transcribe a para. from Assistant Overseer Atkinson's report of this section, from which it will be observed, that he considers the bad construction of a sluice was the cause of this breach. Its occurrence is much to be regretted. The country, the discharge it passed through has covered, is one of the best cultivated in the locality. If this ill-constructed sluice was the primary cause of the breach, very likely the darogah or overseer in charge, did not see to the proper puddling of clay around the sluice masonry, the use of puddle was most probably forgotten or unknown, and when the flood rose against the face of the work, it found numerous vents to escape between the masonry and the filled in clay, and gradually worked a series of larger passages, until the whole blew up, as it were, giving way under the united agencies of erosion and pressure.

"Between the villages Aumtpore and Neelapudda, the country is entirely under water, like a vast lake, in consequence of the meeting

of the water of the Brahmany, Kaloo and Beropa rivers. At the village of Judpore, on the right bank of the Beropa, there is a large breach of about 7 to 800 feet in length, and in some portion of this gap there was a stone sluice built this season by the darogah, but I could not see a vestige of it. Perhaps some trace of it may be seen when the river subsides. I believe the bad construction of the sluice was the cause of the breach, because the flood mark left on the embankments shews that the water was two feet below the crest. I was informed by the villagers on the spot that as the river rose, the water was oozing through the masonry. Section of bund near breach.

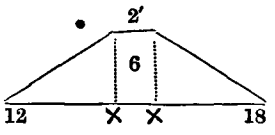


"This breach occurred at 8 A. M. on the 12th August, that is before the flood had gone into the Beropa and the breach at the Aul Rajah's bund. The zemindars have been collecting posts to close it as soon as the river falls, and the current in it is less powerful. I cannot tell the depth of the breach, but at one end it is 15 feet deep. It is difficult to say what immense damage this breach has caused to all the land between it and Pattamoondee, which is covered as far as the eye can reach. There appears to be a greater body of water flowing through this breach, than going in the proper channel, and boats keep on the left bank of the river to ensure their not being swept into the land by the strong current that flows through it. At the village cut a flood mark No. 13 on bur tree about 300 feet from the bund in front of the bungalow. Halted here for the night."

25. No. 16 section, which I consider is in the worst condition of the whole, I shall not attempt to enlarge upon, as the entire of the bunds along the Chota Brahmany and Jumboo rivers, are so entirely useless, as not to deserve the name. They having been deeply overridden and the country behind quickly filled with water to the level of that in the river channels. The breaches are of small size. They are 160 in number and their cubical area form the measurements taken as far as the state of the floods permitted, amounts to 20,19,507 cubic feet. The longest gap cut through these embankments, is in length 370 feet and that of greatest area measures 200 feet × 100 feet × 25 feet = cubic feet 5,00,000.

26. I append an extract from Mr. Atkinson's report on this section.

"At the village of Haldurpoor there are several breaches of 100, 50, 20, 150, 100, and 20 feet in length. Section. At the third breach some houses were carried away, all the above breaches are in a portion of embankment, about a mile in length, and which would require raising throughout 3½ feet. The whole country as far as I could see, was one vast sheet of water. Many of the villages deserted and destroyed by the flood. The people here reported to me, that this was the highest flood ever seen by the oldest men in the place, that is, for a period of sixty years. I did not proceed any further down the Chota Brahmany, as the place was as above described, but went down the Gundkyah river.



"28*th August*.—Started from Haldurpoor and proceeded along the Gundkyah river, and at Kuttermul on the right bank. Cut a flood mark No. 25 on Poldooah tree (the bank under water) just close to village, which was all tumbled down by the flood and only one old man and woman near the place, who would have left it, if he could have got his cattle away. The whole embankment on this river being six miles long, is entirely under water; but a few ant-hills can be seen on it here and there. I was informed that two or three children had been carried away by the floods, indeed something ought to be done here. Crossed the country in my boat to Gobaree river, which is one immense lake. At Linkoonah village on the left bank of the Gobaree, cut a flood mark No. 26 on a large bur tree on bank close to village. Put up here for the night."

27. There is no section numbered 17. That number represented the Juggernauth road when it was connected with this office.

28. Very great damages have occurred in No. 18 section. The breaches are 224 in number, and in area 33,08,640 cubic feet. The three principal ones are respectively 600 feet × 40 feet × 8 feet, 500 feet × 40 feet × 5 feet, and 400 feet × 40 feet × 7 feet.

I have had no special report as yet of this section, but I am informed severe injuries have been sustained by the crops within its boundaries.

29. In No. 19 section near Bhuddruck and Balasore, the darogah reports "no breaches."

The bunds are insignificant I believe, and no large rivers intersect it, perhaps it is only partially embanked, at any rate it demands now no special remark.

30. To resume. The damages collected, present the following Tabular statement.

No. of Section.	Area of breaches.	Probable cost of repair.		
		RS.	A.	P.
12, ...	16,55,279	1,758	11	11
13, ...	22,00,062	2,337	9	0
14, ...	50,00,000	5,312	8	0
15, ...	17,18,170	1,825	8	10
16, ...	20,19,507	2,145	11	7
18, ...	33,08,640	3,515	6	10
19, ...	...	...		
	1,59,01,658	16,895	8	2
Add office expenses and Superintendence, ...		15,000	0	0
And 15 rupees per cent. for office contingent expenses and allowance for rough and imperfect measurements taken just after floods have subsided, ...		2,534	5	3
Total cost for say season 1857-58 for repairs of breaches only, ...		34,429	13	5

31. By this expenditure, I do not anticipate that the embankments will be at all benefited for the future, vide my remarks in paras. 7 to 12.

32. It is, however, just now an unavoidable outlay, but I trust sincerely the day will soon arrive when the Government of this country, will be enabled to grant their attention and their money, to and for needful public works, and that they will direct such a searching investigation, examination and remodelling by able men into, and of these radically defective embankments, which demand and have demanded for years, so great a sum for "annual repairs" without yielding any comparative benefits, that by and by, the remodelled "levees" of Orissa, may cease to be a "mockery, a delusion, and a snare,"* that they will represent what they really are intended to be, may enclose fertile, plenteous and well-protected crops, with wealthy landholders, contented ryots and flourishing villages. The reverse is, I am sorry to say, the present condition of the greater part of the Cuttack

* I ask you to excuse this quotation. It is true, but perhaps a little too pungent.

district. It is most truly in one season of the year drowned, as it were, from the inundations of its rivers, at another parched with drought, at neither period yielding anything like its proper measure of food or fulfilling its duties as a grain-producing country, to other portions of the world.

33. Its exports are almost nothing (salt excepted). Its imports very small indeed. The great natural facilities it affords for a work combining embankments, irrigation, and partial navigation, are well worthy of deep consideration, and I am confident would vie with the most favorably executed ones in the Madras Presidency, especially as regards profit and return on capital invested.

34. I am now taking active steps to have my annual estimates submitted at as early a date as possible. The continuous floods or rather half and three quarter floods, which have occurred in the Mahânuddy this season, have prevented accurate measurements from being taken of the breaches at an earlier period, but I trust to have my estimates forwarded at such a date as will, I hope, ensure my receiving the sanction of Government, to an early commencement of the season's work, a thing very much to be desired.

35. No works have been executed in the mofussil districts since the high flood of August last, I have not attempted to repair any breaches even in a temporary manner, as I well know the flood that created them also inflicted the injuries which hereafter may be complained of, the duration of the inundation being excessive.

36. Earth-work in the rainy season is always expensive, and under the darogah system not correct, as the constant rain fills up or partially obliterates the excavations. Check measurements are not possible unless the overseer is on the spot constantly, and that he cannot be, from the nature of the country, and extent of the breaches to be repaired.

It is only a very peculiar accident I should wish to repair with the materials and under the management the work is to be executed with, the rainy season of the year is however favourable for the execution of consolidated earth-works, but that, I think, is the only advantage.

From the Junior Secretary to the Government of Bengal to the Secretary to the Board of Revenue, Lower Provinces,—(No. 2970, dated 15th December, 1857.)

SIR,

I AM directed to forward herewith an extract (paras. 23 to 25) from a report dated the 1st intant from the Officiating Chief Engineer on the subject of the embankments in the Cuttack division; and to request that the Board will favour the Secretary, on an early date, with a report as to the impediment which is stated by Captain Young to exist to the adoption of one of the plans suggested for providing against the inundations from the Cuttack rivers, and which has, for its object, the entire abandonment of the bunds which have hitherto proved so inefficient.

From the Secretary to the Board of Revenue, Lower Provinces, to the Junior Secretary to the Government of Bengal,—(No. 44, dated Fort William, the 5th February, 1858.)

SIR,

I AM directed by the Board of Revenue to acknowledge the receipt of your letter dated the 15th December last, No. 2970, forwarding an extract from a communication of the Officiating Chief Engineer, and inquiring whether there is any impediment in the engagements entered into with the zemindars of the province of Cuttack, to the adoption of a suggestion which has been placed before Government involving the entire abandonment of the embankments.

2. The Officiating Collector of Balasore, Mr. Schalch, whose reply to the Board's requisition for the required information was first received, says that of 110 embankments in that district on the list of the executive officer, the Government is bound to keep up 40, and that it would be liable to a civil action for any injury that might result from the abandonment of any of these bunds.

3. The Collector of Cuttack says that in the engagements of the zemindars, there is no mention of embankments, but that in each settlement rooedad, there is a paragraph giving a list of the embankments in the estaet, and mentioning whether they are kept up by the zemindar or the Government. This was done under instructions

from Mr. Commissioner Ricketts, issued in November 1838, and the Collector, Mr. Shore, is of opinion that there was an implied condition to keep up the embankments, and that to abandon them without resettling the country would be a breach of faith.

4. The Officiating Collector of Pooree, Mr. Mactier, observes that though the "terms" of the engagements do not bind Government to keep up the embankments, yet that at the time of Settlement there was a tacit understanding that they would be kept up, and that regard was had to this circumstance in estimating the assets of each estate. If therefore the bunds should be abandoned, he thinks the Government is bound either to review the settlement or to grant remissions for losses by inundation.

5. The Board concur with the local officers, whose views were also shared by Mr. Mills (see page 28 of the Selections from the Records of the Bengal Government, No. 3) extracted on the margin.* No change can, they think, be made in the existing arrangements till the expiry of the settlement in 1867-68.

* "At all events the question (namely that of levelling the bunds) cannot and should not be entertained, until the present settlement expires, as in estimating the assets of each estate, regard has been had to the continuance of the embankments which protect them."

From CAPTAIN W. D. SHORT, Officiating Superintendent of Embankments,—(Midnapore, dated 4th November, 1857.)

MY DEAR SIR,

I CALLED at your office several times when last in Calcutta, and was disappointed in not seeing you, as I was anxious to talk over the report on the Cuttack province and the embankment &c., &c., and desirous of learning the result of the deliberations on the subject.

As every evil predicted by me (vide printed memorandum) in January 1855, has actually occurred, except the destruction of the collectorate and city (which, I believe, in the natural course of events must go, unless measures are at once sanctioned, to reopen the Mahanuddy's channel at the head of the Delta, and prevent the flood working for itself a lower level to the south-east and south in the Katjooree,) I am anxious to point out the expediency of removing

the station Civil and Military (vide my report and annexed sketch) to the fine high rocky plateau on the left bank of the Mahanuddy river, which in every way would be a preferable position—and were this once accomplished, the minds of *all* would be permitted to project *good* for the great district (which is now sacrificed) instead of confining their efforts to save a town which, comparatively speaking, is not worthy of consideration.

The line of Telegraph wire will run along the plateau whereon I propose to place to the new station, and I further propose to carry the main road up along the left high bank of the Mahanuddy (the Telegraph posts to run along the interior slope) vide sketches, as far as the narrow rocky gorge (through which the river debouches upon the head of the Delta) and there, to cut a fine ghaut, whence at all seasons a good ferry would work to the opposite hill, where a similar ghaut could be cut with facility. From this point a fine embanked and well-retired road would run over the high ground on right bank of the Katjooree river (the head of the Baruny nullah must under any circumstances be permanently closed by a stone weir) and be connected with the present road to Ganjam and Madras. Thus the difficult passage of the Mahanuddy, two half miles, and that of the Katjooree would be avoided, and a fine ferry be established across the neck of the river at Naraj (but 2000 odd feet across) and during the floods, the ferry would be maintained in the same way as those are over the river and other mountain torrents in Switzerland. Indeed I believe before ten years are over a Stephenson will have a bridge across the Mahanuddy (if necessary) where I propose the ghaut should now be made.

I am convinced that eventually it will come to this, and if Engineers of experience, and with enlarged views, are sent to examine, they will, I believe study the Government interests by coinciding in these views, you would then have upwards 6 lakhs (I do not think I am exaggerating the amount) of valuable ready cut stone for the great work projected by me, or any improvement thereon, in January 1855, wherewith to control the floods at the head of the Delta, when the southern and south-eastern district of Cuttack could be readily supplied by well-regulated irrigation channels, and this district would become the granary whence to supply (via the water-communication by the coast, which can also be readily improved) the less favoured

districts along the Madras coast, as also the Calcutta market. The way to study the capabilities of the Cuttack district is to *imagine* it your own farm; and certainly an intelligent European community with capital, engineering skill at its disposal, and *order*, and with a knowledge of the peculiar advantages enjoyed by this fine district, and particularly with the experience gained by works (to obtain the same end) in the Madras Presidency, would obtain a return of cent. per cent.—Indeed it appears to me that, with material at hand, labour available,—indeed everything *coaxing* the authorities to act,—the order on the part of the Government to act, and energy in the Executive, is alone wanting to ensure success.

My report has, I believe, clearly shewn, that whilst reams of paper have been expended in calling for the reason of breaches and lamenting the deterioration of the district, ignorance of the real root of the evil has caused the delay in applying the remedy. The Mahanuddy had for centuries and centuries rolled along its channel to the sea through the centre of the central Cuttack division and, owing to the causes shewn in my report, has since 1840 thrown off yearly, viâ the Katjooree, an excess volume of flood, to meet which, neither the natural channels, nor the original artificial levées were formed or constructed, and ignorance naturally cries out against the inefficiency of the embankments.

We must first control the Mahanuddy at the head of the Delta, when anxiety will cease: there will *then* be no reports and plans to save the town, and raise embankments, but compensation will be given to the people to move, or (after removal of the entire revetment for the great work at the head of the Delta), the Katjooree bank can be sloped and turfed and protected along its base by cheap brushwood operations, and a heavy earthen embankment raised to protect them (vide sketch).

It is exceedingly unpleasant to hear of the success on the Madras side, when we might carry out, with greater success, similar works on our side, taking advantage of their experience.

I have just received a private copy of Col. Baird Smith's report on the Madras works, and at the expense of occupying your valuable time would make the following extract—or rather refer to four particular portions of the work, viz., pages 10, 27, 31, 55—and having in January 1855 shewn the *root* of the evil, pointed out the remedy, and projected

a measure (vide E. F. G. in sketch) which at *that* time (in ignorance of the Madras works) I deemed the best, but which I would now abandon for the weir C. D., I would hope that twenty-five years may not be allowed to elapse (as in the Madras case),—before the Government is determined to improve the conditions of the land owners and increase their *own revenue*.—Three years have now passed, and the 2nd year after my prediction (which was simply a natural deduction from what I saw progressing) the Mahanuddy's cold weather channel was for the *first time on record dry* owing to the increased scour and lower level created down the Katjooree. The crisis has occurred, and before any catastrophe occurs below, I would urge the adoption of measures to meet the yearly increasing difficulties.

The reason why embankments do not answer the end for which they were intended is because they were originally badly aligned and contracted the water channel, but the cause of their wholesale destruction is simply owing to the system of throwing money away when the effect is patent, without controlling the flood at the head of the channels, where a little timely expenditure would save thousands below. I will not take up more of your time, but would be glad to know, 1st, whether the question of the roads proposed is likely to be taken up, for it is a very practical move and will cost but a trifle, and at the same time protect the Telegraph. 2ndly, whether the Government is likely to entertain the idea of removing the station and taking advantage of the ready material.

I annex a sketch with an explanatory memo.

A. B. Site proposed for the new station, Civil and Military.

C. D. Revised project (by Captain W. D. Short, Officiating Superintendent of Embankments,) for a weir connecting the rock-bound Naraj hill with the rocky Temple Island, whereby an ample basin will be left for the great floods to rush through and scour out along left bank of Mahanuddy. This weir will answer the same end as one across the river, and there will be the additional advantage of the open rocky outlet or channel between the Temple Island and the rocky left bank.

E. F. G. *Original project* by Lieut. W. D. Short, Officiating Engineer, Cuttack division—a flêche of masonry founded upon rock or wells,

to control the volume down the Katjooree and give the direction to that down the main channel. This was projected in 1854, but submitted in January, 1855.

C. H. Weir projected by Captain Beadle, Superintendent Embankments, Lower Provinces, in 1856 *connecting* Naraj with apex of the triangle or island whereon Cuttack is situated.

K. L. Weir projected by Captain Beadle, Superintendent Embankments, Lower Provinces, 1856, across Katjooree.

M. N. Weir projected by Mr. Samuells, across the Kokai.

N. O. P. Weir projected by Captain Beadle, Superintendent Embankments, across the Katjooree and to protect &c., of river.

a. b. c. d. Main road from Calcutta to Cuttack leading to ghaut.

c. e. f. g. h. k. l. Continuation of main road projected by Captain W. D. Short, Officiating Superintendent Embankments, along high left bank of Mahanuddy river, with the Telegraph wire running along the exterior slope to *k*, where the wire will cross the narrow neck of river a width of 2300 feet from *k* to *n*—at *l* a small ferry or toll house might be put, or a small Telegraph office.

l. m. A fine ghaut to be cut in the rock down to the ferry.

h. Do. Do.

n. o. A fine ghaut and road cut through the rock with a good gradient from *o* to *q*.

p. The head of the Barany nullah to be permanently closed by a stone dam, as the water passes now in excess, and answers no useful purpose.

q. r. s. A fine well retired embanked road connected with the present road to Ganjam and Madras Coast.

p. r. A small embankment to prevent any water taking weir in flank and giving it a set towards *r*.

h. B. The immense store of material at hand from and in fort Borabauttee to H. L. P. to be removed and go towards rapid construction of weir (wherever it is decided to make it) and the town to be preserved (as the flood down the Katjooree will be trifling when the weir is carried out) by a heavy embankment under dark dotted line protecting Cuttack itself (the cutchery being given up, or the river will take it).

From the Secretary to the Government of Bengal, to CAPTAIN C. B. YOUNG, Officiating Chief Engineer, Lower Provinces.—(No. 1377, dated 9th April, 1859.)

SIR,

WITH reference to your letter, No. 3656 of the 19th September, 1857, and its several enclosures, which were specially reported to the late Court of Directors under date the 15th October following,* I am directed to forward to you an extract, paras. 133 to 137 of a despatch No. 27 of 4th August last from that Court on the subject of the Cuttack embankments, which has been received from the Government of India in the Public Works Department under date the 8th October, with a request that the matter should receive early consideration and a report submitted on it, but which has inadvertently been left unnoticed.

* *Vide* this office letter, No. 2341 of 14th October, 1857.

2. His honor requests that the Court's remarks may receive your due attention, and that you will submit a report in regard to them, with advertence to the present state of things and the measures taken since the date of your letter above alluded to.

3. I am desired to take this opportunity of stating that your report, No. 1611 of 25th June last, relating to Col. Cotton's report on the Mahanuddy, and the papers submitted by you with Captain Harris's second report on the Cuttack rivers, are now under transmission to the Government of India in the Public Works Department.

Extract from a Despatch from the Hon'ble the Court of Directors to the Government of India, in the Public Works Department, (Revenue),—(No. 27, of 1858, dated the 4th August, 1858.)

133. From the report of Captain Short, Officiating Superintendent of Embankments, it appears that the successful management of the Cuttack embankments by Captain Rigby was first interfered with by an order of the Military Board in March 1847, "prohibiting all but the repairs necessary to prevent actual breaches, while the question of abolition or retention of embankments was under

Answer to Letter (Revenue) dated 23rd December (No. 14), 1857, and to revenue letter, dated 22nd July, No. 13, 1857.
Transmitting two Bengal special narrations occasioned by Court's call for information respecting the causes of the bad state of the Cuttack embankments.

discussion." The Board, though doubtless without intending it, did nothing less than disorganise the existing system, in a matter in which great public and private interests were at stake, pending deliberation on a speculative project, destined to be dropped, for doing away with river embankments altogether. The effect, according to Captain Short, was to stop the usual annual repairs, "and so weaken the then existing sections of embankments, that they were for the future readily breached by any flood more than an ordinary one; and, consequently topped and breached heavily in all extraordinary seasons." Captain Short considers this to have been a violation of faith with the zemindars. It would have been so, if liberal remissions had not been made to avert the losses which ensued. But the remissions made were so large, that we cannot believe this grave reproach to rest upon our Government.

134. This great error of the Military Board was followed by another equally serious, committed by Captain Macleod (who succeeded Captain Rigby in the local charge) with the support of Lieut.-Col. Sage, the Superintending Engineer. Captain Macleod is described by Captain Short as having "swept away by a stroke of the pen nearly one-half of the existing embankments, as fictitious and useless, and in the same spirit expended little or nothing on what remained" (although two seasons of drought, and consequent low level of the rivers, afforded great facilities for putting the embankments in proper condition) and thus "on insufficient data allowed a province to be laid open to inundation." To these errors, Captain Short ascribes the disasters which led to the remarks in our revenue despatch of 22nd October (No. 14), 1856, and he predicts still greater calamities, unless adequate precautionary measures are speedily taken; foremost among which are measures to control the water at the head of the Delta of the Mahanuddy and check the present tendency to a silting up of the main branch of the river, causing the whole flood to pass down the channel of the Katjooree. The inference to be drawn from Captain Short's report is, that until this question is practically decided, it is impossible to determine either the strength which will be required in the embankments or even their best position.

135. Although the errors above adverted to might and ought to have been avoided under any system, the great works which are evidently necessary for the safety of the province could scarcely have been properly planned until by erecting the superintendence of em-

bankments into a separate charge, you made it the exclusive duty of one of your principal Engineer officers to study and apply the principles appropriate to that description of works. Shortly after the adoption of this important improvement, Lieut. Harris, a most competent officer, was appointed to make the necessary surveys and to report on the means of controlling the flood at the Cuttack rivers. Two years have since elapsed, and Lieut. Harris is understood to have completed his surveys; but only a part of his report is before Government, and he has been ordered on field service when, according to the Officiating Chief Engineer (Captain Young), the manuscript of the second part of his report had not yet been commenced. We consider this to have been a further error. It is not probable that the necessity for the services of Lieut. Harris in the field was such, as to require the postponement of the great work to which he had been appointed on account of his special qualifications, and during the non-completion of which, according to Captain Short, danger of actual desolation impends over the province.

136. We direct that the earliest measures be taken for obtaining the remainder of Lieut. Harris's report, that, on its being received, this important subject be taken into immediate consideration and that no unnecessary delay be allowed to elapse in the adoption of measures which yield in point of urgency to none that can engage the attention of your Government.

137. We must at the same time draw your attention to the many imperfections of system and some grave abuses which are set forth by Captain Short in the memorandum annexed to his report. We expect that the whole of his representations will engage the serious consideration of the Chief Engineer and the Superintendent of Embankments, and that we shall receive from your Government at the earliest period which the state of public affairs shall permit, a special report of the measures taken, or of the reasons why measures are not taken, on each of the points brought to notice by Captain Short.

From CAPTAIN C. B. YOUNG, Officiating Chief Engineer, Lower Provinces, to the Secretary to the Government of Bengal,—(No. 2670, dated the 9th August, 1859.)

SIR,

IN reply to your letter, No. 1377, dated 9th April, 1859, forwarding an extract of a despatch, No. 27, of 4th August, 1858, from the late Hon'ble the Court of Directors on the subject of the Cuttack embankments, I have the honor to submit the annexed copy of a letter, No. 693, dated 22nd June, 1859, from the Superintendent of Embankments, furnishing the information called for.

2. As Captain Beadle says in his 5th paragraph, the order to discontinue work to any extent upon the embankments was an order of Government, not given upon the Military Board's advice, and it was owing to the discussion then going on, as to the abolition of all embankments, a measure very strongly recommended by the then Superintending Engineer of the south-eastern provinces, Col. Sage, who was president of a committee, who proceeded up the Damoodah river for the purpose of investigating this question. It applied, I think, to the Burdwan and Midnapore divisions particularly. The subsequent small expenditure in 1849-50 and 1850-51 in Cuttack (vide paragraph 3 of my No. 3656, of 19th September, 1857), was owing to the same conviction on the part of the Superintending Engineer.

3. The Hon'ble Court observe in paragraph 135, that the great works necessary for the security of the province could scarcely be planned properly, until the appointment of a special officer as surveyor of the Cuttack rivers (Captain Harris,) who should study and apply the principles appropriate to such description of works. I am promised the concluding parts of Captain Harris's report, upon which he has been industriously engaged, very shortly. The proper time will then have arrived for the Government to form a conclusive judgment upon the question.

4. In his 9th, 10th and 11th paragraphs the Superintendent of Embankments states that in the interim much has been done for the province, and there can be no doubt, I think, that this is the case. Captain Harris, Mr. Armstrong, Civil Engineer, and Mr. Rayner, have been zealously at work. The embankments have been well repaired and placed in as good order as possible. New sluices have been con-

structed, while the revetment wall has been raised to an uniform level the whole way down the Katjooree left bank; the deep water channel of the river has been shifted, by means of brushwood break-waters, away from the base of the wall which has, in consequence, silted up greatly with sand (vide the sections and report by Mr. Armstrong forwarded with my No. 2967, of 17th August, 1858.) The embankments surrounding the city have also been raised and constructed of such section as to render it comparatively safe, if not altogether so, in case of inundation. The good effect of these measures has been already apparent, the Superintendent states, in the smaller amount of remissions of revenue made during the last four years (vide his 9th paragraph).

5. Lastly, the large stone groyne at Naraj above the city has been constructed, the effect of which will probably be to relieve the Katjooree of some of the surplus water it was carrying off, and to divert the same into the Mahanuddy.

6. Regarding this work, it would appear that Captain Short made a suggestion in his memorandum dated February 1855, that an "artificial spit of stone masonry" should be constructed at the head of the river, (paragraph 12) whereby the flood passing down the Katjooree, being confined between the promontory or spit and the rocky range on right bank, would be lessened in volume, and that in the Mahanuddy increased. This report was transmitted to Captain Beadle in June of the same year. He sent it to Captain Harris saying that it was not clearly written, and that it was not easy to understand exactly what was intended, but that there was much matter for consideration in it. He did not understand Captain Short's project clearly, but he himself thought a groyne of masonry projecting from the bank would be useful. The same idea, he says, occurred to Captain Harris, when going up to the river in a boat to Banka (date not given).

7. Although Captain Short, in a subsequent paragraph of the memorandum alluded to, (paragraph 26) says that he conceives any attempt to force the stream by expensive measures (viz., forming immense stone break-waters in the sandy bed) as so much money thrown away, yet it appears clear that the flêche he himself recommended was to be of this very nature. There is therefore, I think, some confusion in his letter. It may be said that his remark, although stated in general terms, applies only to the Katjooree bed opposite the revetment

(see preceding and subsequent paragraphs). In any case he certainly seems to have recommended a stone work groyne or flêche immediately below Naraj, with a view to regulate the water, and also in the subsequent paragraph of the same memorandum of February, 1855, the adoption of brushwood dams in the Katjooree river bed, with the view of turning off the river from running under the revetment wall and thus removing the deep or dangerous channel to or towards the opposite bank of the river, a work which he says (paragraphs 10, 22, 23,). was successfully performed by him in 1854-55. The same kind of work has been successfully carried out in subsequent years by both Captain Harris and Mr. Armstrong.

8. This report written in February, 1855, was, as before said, sent by the Chief Engineer to the Superintendent of Embankments in June, 1855. The first recommendation for the Naraj stone groyne, as at present being constructed, was made in submitting the first part of Captain Harris's report in September, 1856.

9. My own opinion regarding this work has already been given in my remarks submitted with the 2nd part of Captain Harris's report, viz., that it can be considered as but a temporary measure, and that it would only change in high floods the scene of injury from southern to central Cuttack. The first evil of the country is drought, which nothing but an anicut or .complete weir from bank to bank will avert effectually. The second evil is inundation, from the fact that the river pours down double the quantity of water in inundations which its channels can carry off; and nothing but surplus reservoirs I believe will remedy this. As yet neither of these matters has been taken up in calculation or detail by the surveyor of the Cuttack rivers, the 3rd and 4th parts of his report may, however, treat of them.

10. With regard to the first of these points, Captain Beadle says in his 12th and 13th paragraphs, that one great evil of the province, "as written in large financial figures, is drought, want of water, and not inundation," and as regards the 2nd, in his 10th paragraph: "If the floods directed into the Mahanuddy do not clear out and increase the channels to the extent that the spur has increased their volume, the Cuttack district will be perhaps worse off than before." This, as I think, they will no doubt do to a considerable extent; but it will be at the expense of the Katjooree and its off-shoots, which will, in proportion, be filling up, and the great balance established by nature between

the total amount of all the channels of both rivers and a full flood, will probably remain just the same after, as before, the construction of the spur.

11. Regarding the imperfections of system and grave abuses alluded to by the Hon'ble Court, to the whole of which I am required to give serious attention, I would observe that the first four relate chiefly to the mode of embanking and managing the rivers, and that Captain Short's remarks are, as Captain Beadle says in his 1st paragraph, out of date now; since Captain Harris found, by accurate measurement, that the whole of the river channels of the Delta below Cuttack were only able to carry off one-half the amount which passed the head of the Delta at Naraj in a great flood.

12. To have adopted and recommended Captain Short's suggestions would have involved, as I apprehend, (vide page 7 of his report and the above recommendations, particularly No. 3,)

1*st.* The removal of the whole city of Cuttack to the left bank of the Mahanuddy, with the excavation of "great tanks," "heavy embankments," &c., in and about the new city.

2*nd.* The building of a large masonry flêche or weir in the bed of the river.

3*rd.* The construction of a number of "regulating works," consisting of removing sand, cutting channels, and constructing heavy spurs at the mouths of the various "escapes" from the main branches of the river. Works, I would observe, as full of uncertainty as of expense, and to apply to which the engineering terms of accurately calculated scientific and solid masonry constructions, is only calculated to mislead.

4*th.* The formation of new retired embankments on a judicious system, a proposal which Captain Beadle notices in his 18th paragraph.

13. I think it will be sufficiently clear that he must have been a bold man, who, in the absence of any single calculation in figures, but on Captain Short's own unsupported dictum alone, and while the surveys and measurements and levels of Captain Harris were still in progress and in abeyance, would have recommended such measures as these, which Captain Short may consider "simple and moderate,"* but which appear to me very much the reverse.

* Vide page 40 of his Memorandum.

14. His 5th recommendation can be best understood and dealt with by Government.

15. His 6th speaks of the extensive charge of Executive Engineers, their want of competent assistant surveyors, levellers, &c., and their inefficient and ill-paid darógahs or subordinates. This is true, and although by the new organization of the department and the operation of the Civil Engineering College, much may, with liberality on the part of Government, be remedied, yet it is at present far from being on a satisfactory footing.

16. No. 7 I need not notice.

17. No. 8. Deficiency of sluices.

Real efforts were being made to remedy this, and several estimates for extensive works were sanctioned. They were stopped by the mutinies of 1857, and the consequent restrictive order dated July of that year.

18. No. 9. Low rates of work to the labourer. The rate of wages will adjust itself. The oppression and extortion of the underlings can only be checked by the improved character and position of the subordinates of the department, and by the vigilance of good Executive Engineers.

19. No. 10 depends upon the personal character of the officers of the department, and I do not know what remedy, if any, is proposed for it.

20. No. 11. Weak office establishment. This is an evil no doubt, and one I would myself gladly see remedied. I have proposed a revised scale of office establishment to Government in my No. 9211, of 18th April, 1859, but it is done under the injunction that no increase will be allowed, but that a saving is expected. It cannot therefore effect very much, although, with the aid of establishments charged to works under the rules of the new code, it will tend, I believe, to considerable improvement. I have tried to render it more operative for good by increasing the salaries of head writers, which I consider a very important point. I hope also to be able in time to supply, for the assistance of Executive Engineers, draftsmen and calculators from the Civil Engineering College. In this, I trust to receive also the Government assistance, which I believe the Principal of the College has asked for.

21. No. 12. Frequent changes in officers. This has often been represented. It is almost unavoidable, and Government no doubt deprecate it as much as any one. The evil would be mitigated by good native heads of offices, as already recommended by me; and in my

opinion also by giving some extra allowance or advantages to the European Supervisors or Sub-Engineers employed in the unhealthy divisions of embankments, by which to ensure their stay in them as long as possible.

22. No. 13. Appointment of experienced Sub-Engineers, and the evil of giving them too much account work. This has been partly noticed in the last paragraph. Both are very desirable; but experienced Sub-Engineers are not easily procurable, and it will scarcely be possible to give them less account work than they generally have at present, until the intellectual standard of the native subordinate branches of the department is raised, as it is now being by present rules, and the operation of the Civil Engineering College.

23. No. 14. Breaches and their causes. This is the point especially noticed by Captain Beadle in his 18th paragraph, where he states that he considers Captain Short's descriptions were applicable to the time previous to Captain Rigby's appointment, and also says that much has been done lately in the way of improvement, which I believe to be correct.

24. No. 15. A local head to the embankment department at Cuttack, who, with the aid of a good commissioner, might carry out irrigation, coast navigation, and other improvements. The benefit of this, I believe Government is prepared to admit.

25. No. 16. A new outlet to be cut to the Chilka. This is being done during the present year. It is not an expensive matter, and will, at any rate, afford a temporary relief to the lower channels of the Pooree district.

From Captain J. P. Beadle, Superintendent of Embankments, to the Officiating Chief Engineer, Lower Provinces,—(No. 693, dated Lower Provinces, the 22nd June, 1859.)

Sir,

In acknowledging the receipt of your docket, No. 59, dated 4th May, 1859, the Bengal Government's No. 1377, dated 9th April, 1859, and the extract from the Honorable Court's despatch in the revenue department to the Government of India, No. 27, of 1858, dated 4th April, I must observe that the memorandum of Captain Short to which the above documents refer, is now out of date; the memorandum was written before the calculations of Captain Harris's

excellent survey of the Mahanuddy had proved that the Delta channels of that river were only capable of passing off to the sea half of a maximum flood, and that during the period of a maximum flood, 9,00,000 cubic feet of water per second have to find a place somewhere, until the subsiding river allows of the surplus flood draining off by the Delta channels.

2. This astounding deficiency of water channel in the Delta of the Mahanuddy, had evidently not entered into Captain Short's mind, for throughout the memorandum he considers it only necessary to direct and distribute the waters at the heads of the successive bifurcations, commencing at the first great one at Naraj.

3. Two short extracts will show this; in the 31st page speaking of the Mahanuddy, Captain Short states "That the channel was and is fully equal to contain its flood without detriment to the country" and in the 38th page, writing of the Pooree division embankments, he states as his opinion that "the embankments will be unnecessary, when the flood at head of Delta is controlled."

4. It is consequently clear that Captain Short was not aware of the first great evil we have to contend against, a flood 9,00,000 cubic feet per second in excess of what the Delta channels in the Pooree and Cuttack districts, embanked as they are, can contain and carry off to the sea, and that he had only the second great difficulty of the river in his mind, that of the re-distribution of the waters by forcing the full volume down the Mahanuddy branch which that Delta river and its channels can contain and carry off.

5. I would now turn to the late Honorable Court's 133rd paragraph, which reflects severely upon the late Military Board. The order in question to discontinue work was neither the Military Board's order nor the effect of the Board's counsel, but an order of the Government issued to the Board, which, if I remember rightly, was countermanded in October of the same year in which it was issued, and in consequence of the Military Board's remonstrances. I rather think too, the order only applies to the embankments of the Midnapore districts. The facts however can be easily supplied by a reference to Mr. Byrn, who has his note book, and you will perhaps remember them, having at the period in question been in the Board's secretariat.

6. I do not also draw the same conclusions that Captain Short does as having resulted from the above order.

The breaches in 1847 only aggregated 3½ furlongs.

$\frac{1}{12}$ per cent. of the whole length, say 600 miles.

in 1848.....1 Mile	This includes Balasore Division also.	$\frac{1}{6}$ per cent.
in 1849.....2 Furlongs		$\frac{1}{24}$ per cent.
in 1850.....2 „		$\frac{1}{24}$ per cent.

While the remissions were in

1847.....Rs.	1,178	In Cuttack or Pooree
1848..... „	8,369	
1849..... „	1,776	
1850..... „	1,476	

so that neither the breaches nor the remissions for the year of the order, and for the subsequent years, were of any great importance; moreover, the expenditure during 1847-48 and 1848-49 shows no great falling off, having amounted to 21,546 Rupees and 14,956 Rupees respectively.

7. The mistake Captain McLeod and Colonel Sage fell into in 1849, was a more serious one, and there is no doubt but that the embankments deteriorated, and that these officers in their desire to economize expenditure and to do away with embankments, fell into extraordinary mistakes in regard to the facts of the river and its various channels; still the expenditure was very small,* and the aggregate of breaches in 1851, was only 3½ furlongs; and in 1852, 2 miles 6 furlongs; the remissions amounting to 5,614 rupees in 1851, when there was a severe gale from the sea; and to 42,537 rupees in 1852.

* Only 853 Rupees in 1850-51.

8. With a knowledge of the fact that the great floods have an excess volume calculated at 9,00,000 cubic feet per second, one can only feel that it was a mercy that the embankments had not been continuously raised and strengthened up to the period of the great floods arriving. The catastrophe would only have been the more disastrous, and the loss of life, of which we have not heard, might have been very great indeed, for the flood level would have risen higher, and the city of Cuttack must have been swept across by a flood from the Katjooree rushing into the lower level of the flood in the Mahanuddy.

9. Matters have happened for the best, and I observe that during the 4 last years of great floods, only 119 rupees have been remitted in

1854-55
1855-56
1856-57
1857-58
See Captain Harris' Table 14, page 109 of the papers recently published.

For ordinary losses no remission is made in central Cuttack, and losses are considered ordinary, when they do not exceed one-fourth of the produce, the assessment has been made accordingly.
(Signed) J. P. BEADLE,
Superintendent.
The 20th June, 1859.

Cuttack, and 1,29,149 rupees in the Pooree division, and the past season (1858-59) has been a year of abundant crops, placing Orissa in comparatively easy circumstances, and we have now the advantage of much better embankments in Pooree than that district has ever had, with the advantage of a stone spur at Naraj to diminish the floods entering the Pooree district, and to turn the greater volume of waters down the Mahanuddy side. The revetment of the city is also secured from the action of the river which used to undermine and bring it down.

An additional escape to the sea will be furnished for the Pooree floods by connecting the Sur lake with the Koosbuddra, and I am also prepared to open out the Chilka to the tides during this flood season, the civil authorities offering no objections to the cut being made, in consideration of the advantages this great measure of relief will afford.

35th page of Captain Short's Memorandum.
A great deal has been written about the Chilka lake, but any one looking at a good map of Egypt will see that at the mouth of the Delta channels of the Nile, are two somewhat similar lakes.
Lake Bourlos with its old Sebennytic mouth and Lake Mareotis.
(Signed) J. P. BEADLE,
Superintendent.
The 20th June, 1859.

10. Thus the Pooree district of Orissa may be considered as somewhat extricated from the flood rule to which it has been subjected of late years, but the most important question has not been met. If the floods directed into the Mahanuddy do not clear out and increase the channels to the extent that the spur has increased their volume, the Cuttack district will be perhaps worse off than before. The floods entering at the Delta head must be reduced by retarding the rush of the river to the Delta, and this question still occupies Captain Harris, and will shortly be reported upon.

11. The Mahanuddy is a large question, the problem to be solved was a very difficult one, the actual steps taken have been carefully and cautiously made, and have had great results at a small expenditure.

For report on these see my No. 2840, dated 15th January, 1859, stating the results of Captain Harris's work as shown in the safety of the revetment wall and regulation of the volume at the Delta head, reducing the level to which the floods rise on the Katjooree side of the town of Cuttack.

I have recently re-perused almost all the correspondence since 1854, and have seen how sure has been the progress made in dealing with this river

and in acquiring a knowledge of its laws and volume; I am confident a greater haste would not have been profitable, and if the papers already published have not stamped the intrinsic value of Captain Harris's survey, I am sure he will find, after some time, when his plans and projects in their entirety are published, as I hope they finally will be, together and alone, that their excellence and value will be fully acknowledged. I stand upon this survey as one of the best things of its kind ever done in India, and I believe its results will be as important.

12. Turning to Captain Short's 9th paragraph, I would remark that the 23 lakhs of Rupees remitted in nine years, were remitted *before* the present settlement; and it is a circumstance, which should not be overlooked that only 1,86,942, of this amount was remitted on account of inundation, all the other sums being remitted on account of "severe drought, want of water, and failure of the harvests, and an early cessation of the periodical rains." This was stated in the 82nd and 83rd paragraphs of my Report* see page 21 of the reports and correspondence printed in 1857. Thus Captain Short's argument fails; for an "investment of capital to counteract the root of the evil" would have done nothing towards preserving the country from the effects of drought.

6th paragraph, 58th page of Captain Short's memorandum.

*Taken from a report by Moffat Mills, Esq., when Commissioner of Cuttack, a safe guide.

The enlargement of the Katjooree head has been styled "the root of the evil."

13. Indeed the great evil of the province, as written in large financial figures, is drought—want of water—and not inundation, although for the last six years, inundation has been the destructive agent, but remissions on account of inundation are trifling compared with those made on account of crops failing for want of water.

14. In his 7th paragraph, Captain Short refers to his report of January,* 1855, which, he believes, if submitted to Government for favorable consideration, would have produced certain orders which he enumerates. I referred to this memorandum in the postscript of my report of 21st August, 1856, see 23rd page of the proceedings printed in 1857, and the neglect of the memorandum does not lie with this office.

* Should be February.

7th paragraph, 7th page of Captain Short's memorandum.

15. I first visited Cuttack in December 1854, and Captain Short was there as well as Captain Harris; the relieved and relieving officers;

it may be asked why I did not take up Captain Short's views, why I did not proceed to Naraj, why Captain Harris did not at once go there? The answer is, that Captain Short made no communication to us on the subject, and that he left no record in the Cuttack office of the nature of the facts and opinions stated in his memorandum, which, it will be seen from the 55th page of the printed correspondence (1857), was written at Midnapore, more than two months after he had given over charge of Cuttack, and it was not forwarded through me, but direct to the Chief Engineer's Office in Calcutta; and no communication was made to me on the subject of this memorandum by the Chief Engineer or by the writer of it till June, 1855, and neither Captain Harris nor myself had any knowledge of the statement made in it, which is much to be regretted, for we should certainly have been six months earlier in the field respecting the Naraj spur, if we had been placed in possession of the observations of the Executive Engineer in December, 1854, and it was not till Captain Harris went up the river in a boat to the Bankee estate to do some work for the Commissioner, that, passing through the rock-bound neck, he conceived the project of the spur which is now nearly carried out, and to show how the same idea immediately struck me when I was favored with Captain Short's memorandum, I append a copy of my letter No. 600, dated 7th July, 1855, addressed to Captain Harris.

16. It seems necessary to make this statement when stress is laid upon the memorandum of 1855, and I must further remark upon the observations made in the 10th page of Captain Short's report under reply, in which he says that "There can be no question regarding the ignorance of all parties up to December, 1854, as to the necessity of controlling the volume of water at the head of the Delta, for no individual had ever suggested aught to invite attention to this the main point," and quote the late Military Board's letter No. 9766, of the 10th April, 1849, which, as I stated in my report of 1858, page 7 of the 2nd part of the Mahanuddy printed papers, would, if carried out by the Executive Engineers, in however rough a way, have discovered the cause of the excessive floods in the Pooree district.

10th page of Captain Short's memorandum, cause firstly.

"I am directed by the Military Board to request that you will issue instructions to the present Executive Engineer of the Cuttack Division, to make an accurate survey of the Mahanuddy where it runs

into the Katjooree, showing the positions, extent and nature of the obstructions, and sandbanks that exist at the mouth, and which turn the Mahanuddy's water sharp round the right bank of the Katjooree. The bank of the Mahanuddy should be accurately delineated for the half mile up the river above the Katjooree, and a level should be taken across the bed of the Katjooree in the line of bank of the Mahanuddy."

17. The regulation of the flow of the flood at every channel head is necessary; we have been hitherto occupied with the first great bifurcation, and the change at the Delta head will produce so much change throughout the Delta branches, that observation based on inspections made prior to 1855, cannot be taken for more than their value, each head shall be examined after this season with special advertence to the action of the spur, and the subject will be carefully treated.

17th to 29th pages, inclusive of Captain Short's memorandum.

18. Pages 30 to 50 of Captain Short's memorandum embrace so many points, that it is difficult to notice them; he recommends the formation of new retired embankments on a judicious system; but the land-falls and the retired embankments would occupy lower ground than the marginal ones, and it would be better not to have embankments than to have inland retired lines. He seems quite to overlook the careful instructions issued since 1847, for a more workmanlike construction of embankments, which have noticed every point Captain Short alludes to, in fact his description seems to me to apply rather to the period before Captain Rigby's incumbency of the Cuttack division, who introduced system and did a great deal of excellent work, than to the present time. The establishments although improved in some respects are not good working establishments, and the very moderate scale of establishment, I applied for in 1855, should have been granted; too much depends at present on the working qualities of the Executive Officer, and I would recommend that the proportion entered in the margin, should be adopted in Orissa: it is the basis of the scheme I submitted in 1855.

19. I hope it is not necessary for me to follow the memorandum under comment further. This department has worked up-hill to make the embankments of the Pooree district efficient, and the fact of the floods of last year having filled the embanked channels to the brim without doing material damage, has given us some satisfaction in return for the labour bestowed. Captain Harris is now on the point

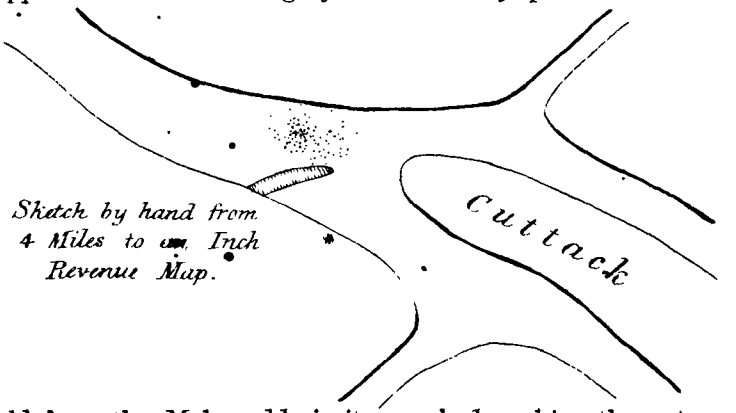
of submitting his final survey and reports, and this year will show to what extent the spur will cause a deepening of the Mahanuddy. I fear drought more than floods, great as these last are in Orissa, and the necessity that exists for storing water for supplies to the thirsty land during years of scanty rains must not be lost sight of, in endeavouring to arrest and direct the action of a great flood. To make the country secure, measures must be taken to arrest the waters, to make it prosperous, the evils of local drought must be mitigated by furnishing, by artificial means, water to irrigate the cultivated lands; but it will not be safe to commence works for this purpose till the river flood has been placed under control.

Extract from a letter No. 600, dated 7th July 1855, to the address of the Executive Engineer, Cuttack Division of Embankments.

I HAVE recently returned to you the plans and sections of the Katjooree river and Cuttack revetment, and I now enclose a memorandum written by Lieutenant Short, apparently during February last, but only submitted to me on the 30th June.

2. This memorial, though ramblingly written and not definite in its conclusions, affords much matter for consideration. If the Katjooree is year by year receiving more water from the Mahanuddy and enlarging its channel, we must adopt measures to arrest this process and to regulate the supply to the Katjooree.

3. I do not understand what Lieutenant Short's project, is, but it appears to me that a groyne of masonry placed as in Sketch A,



would keep the Mahanuddy in its own bed, making the entrance into

the Katjooree rather by a back water than by a direct flow. According to the old revenue maps, the Mahanuddy channel is choked with sand-banks, which are caused by the direct flow into the Katjooree, and these, the Mahanuddy flood, directed by a substantial solid work of masonry in the position indicated, would soon disperse. This work would cost a large sum of money, but the interests at stake are so large, that, if the project were successful, the outlay would be an economical one.

From RIVERS THOMPSON, ESQ., Junior Secretary to the Government of Bengal, to the Officiating Secretary to the Government of India, Public Works Department,—(No. 4002, Fort William, dated the 23rd November, 1859.)

SIR,

WITH advertence to that portion of Secretary Colonel Strachey's communication, No. 4966, dated the 8th October, 1858, which relates to the notice taken by the late Court of Directors of Captain Short's report of August 1857 on the condition and general management of the Cuttack embankments. I am directed by the Lieutenant-Governor to forward, for the information of the Government of India and for communication to the Home Authorities, the accompanying copy of a Report* on the subject, from the Officiating Chief Engineer, together with a copy of its enclosure, from which will be seen the present condition of the embankments and the effect of the measures taken to improve their efficiency and to bring under better control, the annual floods which prevail in that part of the country.

* Letter, No. 2670, dated the 9th August, 1859.

2. The papers now forwarded also show that some of the opinions expressed by Captain Short in regard to the most effectual way of directing and distributing the flood waters are proved by Captain Harris's subsequent surveys and calculations to require very considerable modification.

3. The second portion of Captain Harris's report is now before the Supreme Government, and I am directed to mention that the general question respecting the Cuttack embankments will be taken up by the Lieutenant-Governor on the receipt of Captain Harris's final report, which, it will be seen from the Officiating Chief Engineer's letter, may be shortly expected.

MEMORANDUM.

The Plans and Sections relating to Captain Harris's Report, Part I. have been separately printed; the correspondence relating to the brushwood operations in the bed of the Katjooree, the Naraj spur, and the navigation of the Mahanuddy river, have been printed as Part II. of "Selections," Vol. XXXV.; and the correspondence relative to Col. Cotton's report, and Parts II. and III. of Captain Harris's report and the drawings accompanying Part III. have been printed in separate Volumes.

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